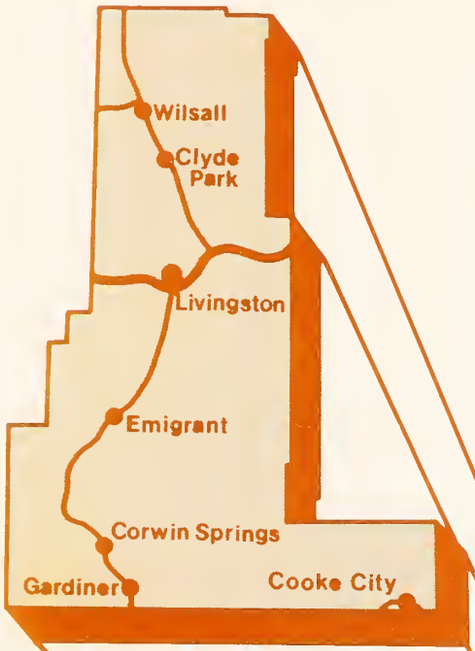
Park County



HIGH HAZARD LOCATION STUDY

RPA Robert Peccia & Associates

December 1982

ROBERT PECCIA & ASSOCIATES
Planners - Engineers - Designers
810 HIALEAH COURT
HELENA, MONTANA 59601 406/442-8160

February 25, 1983

Board of County Commissioners
Park County
Livingston, Montana 59047

Transmitted herewith is the final report for the Park County High Hazard Location Study. This report documents the results of the traffic studies and surveys performed in the evaluation of six locations in Park County.

Included in this report are: 1) a thorough assessment of the existing conditions at each site; 2) an accident analysis of all reported accidents at each site during the four-year period from January, 1978 through December, 1981; 3) a short-term, low-cost improvement program complete with a prioritized project list based on the relative hazardousness of each site; and 4) a series of long-term, more expensive solutions, generally involving road reconstruction.

It has been a pleasure working with you, and we appreciate your guidance throughout the project. We hope you are satisfied with this report and find it useful in reducing traffic hazards in Park County. If you have any questions or are in need of additional information, please don't hesitate to contact us.

Respectfully submitted,

ROBERT PECCIA & ASSOCIATES

Robert J. Peccia

Robert J. Peccia, President

Douglas E. Widmayer

Douglas Widmayer, Project Engineer

DW/gp

PARK COUNTY HIGH HAZARD LOCATION STUDY

Prepared For:

Park County, Montana

In Cooperation With:

State of Montana Department of Justice

Highway Traffic Safety Division

and

the Montana Association of Counties

Prepared By:

Robert Peccia & Associates, Inc.

Helena, Montana

January, 1983

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* Due to the nature of Sites 1 and 6, only Figures A and B are presented

PHOTOGRAPHS

Photo plates are included for each site in their appropriate sections.

CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

The purpose of this report is to evaluate six hazardous road locations in Park County and to recommend appropriate improvements. The sites were chosen by Park County with the assistance of the Department of Justice, Highway Traffic Safety Division, based on accident history and roadway characteristics. The sites are referenced in Table 1 below and shown on a location map, Figure I-1.

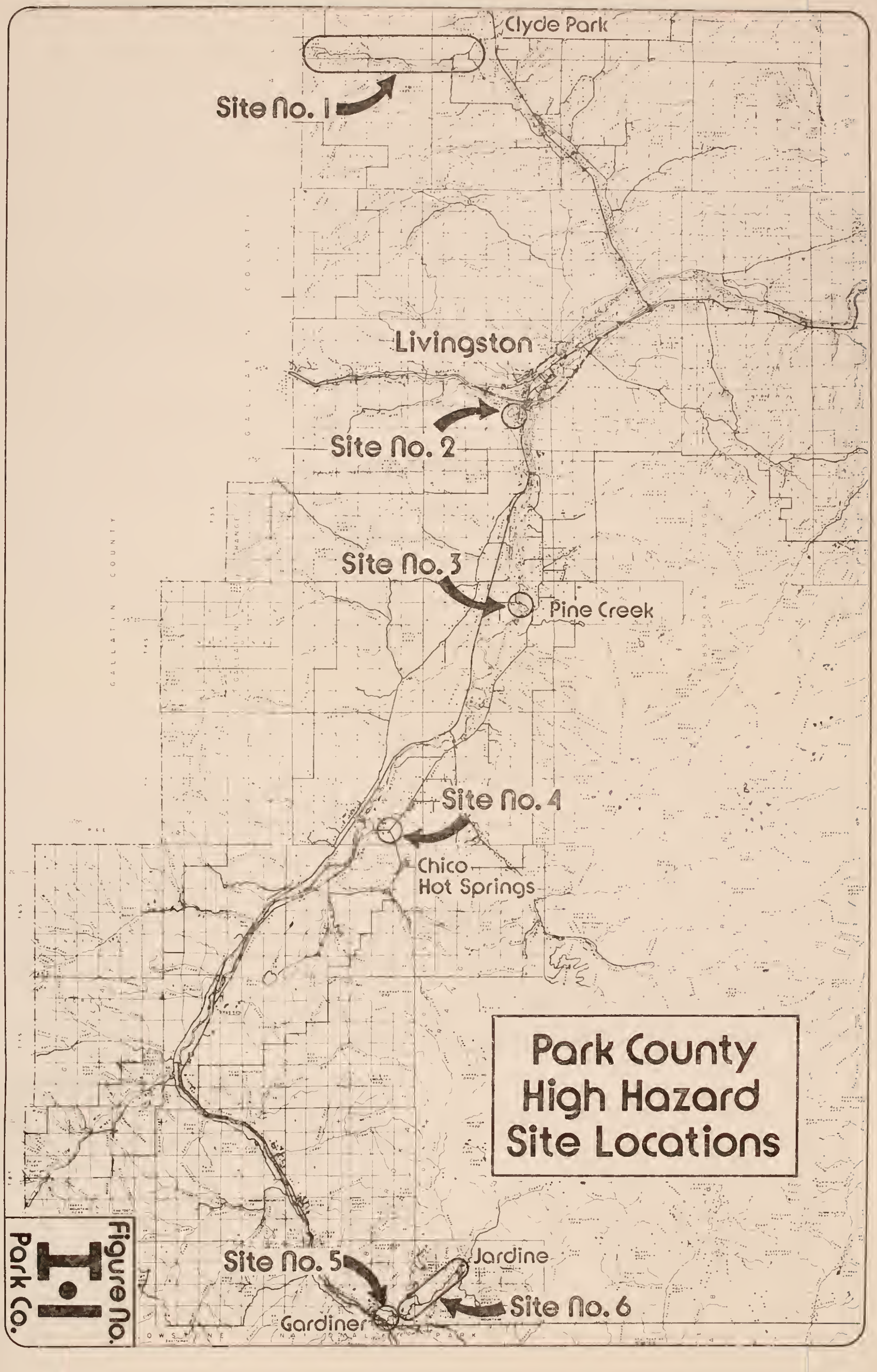
The analysis contained within this report is based on procedures outlined in Report No. FHWA-RD-77-83, Identification of Hazardous Locations, as refined by DCA Project No. 79-04-01-01, Preliminary Evaluation Program for High Hazard Location Study, Yellowstone County, Montana.

Short-term and in some cases long-term improvements that would reduce or eliminate hazardous conditions have been included for each site. Emphasis was given to relatively low-cost improvements in an effort to present solutions within the funding capabilities of the County. A priority ranking of site improvement projects was developed based on a composite hazard ranking and benefit/cost ratios.

TABLE NO. 1

LIST OF SITES

Site #1:	Brackett Creek Road
Site #2:	Billman Creek Lane
Site #3:	Pine Creek Bridge over the Yellowstone River
Site #4:	Intersection of East River Road (FAS 540) and Chico Hot Springs Road
Site #5:	Lower Jardine Road (Gardiner)
Site #6:	Upper Jardine Road


Clyde Park
Site No. 1
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Park County
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Site Locations
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Gardiner
Figure No. 1
Park Co.

CHAPTER II
SUMMARY & RECOMMENDATIONS

CHAPTER II

SUMMARY AND RECOMMENDATIONS

A. Summary

The purpose of this study is to identify the factors contributing to unsafe traffic conditions at six hazardous locations selected by Park County, and to recommend improvements that would remedy the unsafe conditions. At each location, a field inspection was made, the site geometrics were recorded, site condition sketches were made, and manual and machine traffic counts were taken. In addition, the accident records for the last four years were obtained from the Department of Justice and analyzed.

Solutions to the problems that were identified included short-term low-cost traffic management-type improvements, and long-term more permanent solutions generally involving road reconstruction and higher costs. These recommended improvement costs are summarized in Table 2.

The six hazardous sites selected by Park County had 30 accidents reported during the four-year period from 1978 through 1981. These accidents included 1 fatality, 10 injury and 19 property damage accidents. The annual cost of these accidents, according to National Safety Council figures, is $59,633. Based on the average accident reduction figures established by the Department of Highways, the short-term improvements recommended in this report could eliminate 50 percent of these accidents.

B. Short-Term Improvements

The short-term improvements recommended for each site concentrate on supplying better guidance to the motorist through conventional signing and striping methods and on improving sight distance within existing right-of-way limits. The total cost of all short-term improvements is $14,996, based on current construction costs.

C. Long-Term Improvements

Long-term improvements were recommended where deficiencies at a site could not be completely corrected by short-term, low-cost improvements. The long-term improvements generally consist of minor road reconstruction. Due to the nature and the time frame involved with these long-term improvements, it is recommended that they be implemented as funds become available. The total cost of all the long-term improvements is $41,850, based on 1982 construction costs.

TABLE NO. 2

SHORT- & LONG-TERM IMPROVEMENT COSTS

Site No.	Site Name	Short-Term Improvement Cost	Long-Term Improvement Cost
1.	Brackett Creek Road	$3,456	$ 7,000
2.	Billman Creek Lane	1,369	*
3.	Pine Creek Bridge over the Yellowstone River	1,652	6,250
4.	Intersection of East River Road (FAS 540) and Chico Hot Springs Road	448	2,500
5.	Lower Jardine Road (Gardiner)	4,151	*
6.	Upper Jardine Road	3,920	26,100
Total Cost:		$14,996	$41,850

* At Sites 2 and 5, the short-term improvements adequately addressed the problems; therefore, no long-term improvements have been recommended.

D. Prioritization

To aid the County in deciding the order of implementation for the short-term improvements, a Priority Ranking has been provided. This ranking evaluates the relative hazardousness of each site and the cost of the short-term improvements.

To evaluate the relative hazardousness of each site, a Hazard Index was calculated. This Hazard Index is based on three accident indicators (number of accidents, accident severity, and accident rate) and four "non-accident" indicators (volume/capacity ratio, sight distance ratio, driver expectancy, and information system deficiency). Each site has been ranked according to the accident and non-accident indicators, and the Hazard Index is shown in Table 3.

To determine the proper order of implementation for the short-term improvements, the cost of the improvement must be evaluated with respect to the average traffic volume and the site's Hazard Index. Cost factors and benefit/cost ratios were calculated for each site improvement, and are shown in Table 4.

A Priority Index, which is a weighted average of the Hazard Index and the Cost Factor, was computed for each site. The Priority Index ranking is the recommended order of implementation and should be used as the major consideration in selecting the order of funding for these sites. Due to possible funding limitations, it may be advantageous to skip one or two improvement projects in order to implement a greater number of improvements. The Priority Index ranking of the short-term improvements is shown in Table 5.

No prioritization has been offered for the long-term improvements due to the costs involved. It is recommended that the long-term improvements be implemented as funds and/or right-of-way become available.

E. Implementation

The short-term improvements recommended in this report address the major problems at each site. After evaluating the availability of funds, Park County should schedule the implementation of the short-term improvement projects according to the priority listing shown in Table 5. Due to the relatively low cost of these improvements, it is believed that implementation could be scheduled over a two- to three-year period without becoming a financial burden on the County. It is recommended to complete the short-term improvement program prior to funding any of the long-term improvements.

All long-term improvements are considered of equal importance and should be implemented as funds become available.

Throughout this report, when warning signs are recommended, the 30" x 30" size sign is to be used. Likewise, all advisory speed plates should be of the 18" x 18" size. The placement of all signs, delineators, guard rails, and pavement markings should always be in conformance with the Manual on Uniform Traffic Control Devices.

TABLE NO. 3

HAZARD INDEX RANKING

Ranking	Site No.	"Accident" Indicators
1	1	41.53
2	3	41.28
3	5	40.51
4	6	40.22
5	2	31.94
6	4	29.84

Ranking	Site No.	"Non-Accident" Indicators
1	2	34.51
2	5	33.79
3	6	30.21
4	1	29.06
5	3	27.36
6	4	14.05

Ranking	Site No.	Hazard Index
1	5	74.30
2	1	70.59
3	6	70.43
4	3	68.64
5	2	66.45
6	4	43.89

TABLE NO. 4

BENEFIT/COST RANKING

Ranking	Site No.	Short-Term Improvement Cost	Cost Factor Indicator	Benefit/Cost Ratio
1	5	$4,151	80	3.23
2	4	448	98	3.21
3	1	3,456	70	1.75
4	6	3,920	81	1.48
5	2	1,369	99	1.00
6	3	1,652	90	1.00

TABLE NO. 5

PRIORITY RANKING OF SHORT-TERM IMPROVEMENTS

Priority Ranking	Site No.	Site Name	Short-Term Improvement Cost	Priority Index
1	5	Jardine Road (Gardiner)	$4,151	75.73
2	2	Billman Creek Lane	1,369	74.59
3	3	Pine Creek Bridge over the Yellowstone River	1,652	73.98
4	6	Jardine Road	3,920	73.07
5	1	Brackett Creek Road	3,456	70.44
6	4	West River Road and Chico Hot Springs Road	448	57.42

CHAPTER III
PROCEDURE & METHODOLOGY

CHAPTER III

PROCEDURE AND METHODOLOGY

A. Field Investigation and Data Collection:

The conclusions and recommendations contained in this report are the product of an extensive data gathering procedure undertaken for each high hazard location. It is impossible to obtain a realistic view of conditions at a particular site without firsthand experience at the site. The background data collected during initial research and on-site visits revealed the circumstances that make one particular location more hazardous than another. The data gathering procedure used during this study included (in chronological order): 1) initial accident research; 2) initial site visit and site identification; 3) site survey; 4) site photography; 5) detailed site sketch; 6) traffic counts; 7) on-site accident analysis; 8) ball bank testing; 9) sight distance determination; 10) subjective rating of site drivability and physical layout; and 11) observation of driver characteristics and quality of travel. The following section contains a brief explanation of each activity undertaken by two field technicians during the data collection stage of this project.

1. Initial Accident Research

The Montana Department of Justice, Highway Traffic Safety Division initially identified accident clusters for individual counties from historical accident reports and accident location plot maps. The accidents within a particular area were then summarized in a list and submitted to Robert Peccia & Associates. All accidents listed were then retrieved and copied from microfilmed records of accident reports. The accident reports were grouped by general location and listed in chronological order. Accidents that occurred during the study period (January, 1978 to December, 1981) were used for further analysis. Those accidents that occurred before or after the study period were retained for reference.

2. Initial Site Visit and Site Identification

The initial visit to each cluster area was made with a representative of each county, if possible, and a representative of the Montana Department of Justice. At this time, the specific high hazard location was identified through the analysis of each group of accident reports and through the input of the local representative. The firsthand knowledge of the long-term accident history and traffic characteristics at each site thus obtained was extremely beneficial.

3. Site Survey

Field technicians utilized survey equipment to identify the physical layout of the roadway itself. Data gathered during the site survey included av-

erage road grades within the site, roadway alignment, superelevation in curves, roadway widths, and identification of right-of-way widths.

4. Site Photography

During site visits, many photographs were taken to illustrate site characteristics or to identify deficiencies within the site. These photographs were utilized in many ways during the preparation of the report and the report graphics. Aerial photography at the largest scale possible was obtained and used during base map preparation and site analysis. In most instances, the combination of aerial photography and extensive "on the ground" photography minimized the need for return visits to the sites.

5. Site Sketch

Sites were stationed at 100-foot intervals and the locations of significant features were mapped. This phase of the data collection involved extensive field measurements of site details including site locations, pavement marking changes, roadside delineators, utilities adjacent to the roadway, fencing, and roadside vegetation. Site photography was also extensively utilized to produce accurate sketches.

6. Traffic Counts

Available traffic count data was obtained from the Planning and Research Bureau of the Montana Department of Highways and used for as many sites as possible. For those sites lacking such information, 24-hour recording traffic counters set to record traffic volumes in 15-minute intervals were set at the required locations. If the site included a major intersection and traffic was significant, peak hour turning movements were conducted in addition to 24-hour traffic counts. This traffic data was used to determine the average daily traffic (ADT) and for capacity analysis. Traffic counts conducted by Robert Peccia & Associates were submitted to the Department of Highways to augment their traffic count data.

7. Accident Analysis

All reported accidents for each specific site location that occurred during the study period of 1/78 through 12/81 were plotted on collision diagrams. Accident data for the study period was also summarized and used in the field. These summaries allowed the field technicians to reconstruct the accidents and to better understand the circumstances that made for unsafe driving conditions at a particular site. The number of accidents and traffic volumes were used to compare accident rates of specific sites.

It should be noted that alcohol-related accidents have been categorized in two ways on the accident data summary sheet contained in each site analysis. In the first instance, alcohol was listed as a possible violation by the driver of the vehicle (i.e., driving while intoxicated.) In this item, alcohol was treated in the same manner as reckless driving, speeding, and other driving violations. In addition, an accident tally was completed that summarized the number of times drinking was listed as a possible violation and identified the number of accidents that had some form of alcohol involvement by the driver or passengers.

8. Ball Bank Testing

The vehicle utilized during field data collection was equipped with a ball bank indicator or safe curve speed indicator. The instrument provides a simple way to establish the safe advisable speed necessary to comfortably pass through a curve where no speed restrictions exist. The posted advisory speeds on curves were also verified through the use of this instrument. Only those sites with unrestricted traffic flows were tested.

9. Stopping Sight Distance Determination

Sight distance is a major element in the safe and efficient operation of any roadway. Stopping sight distance, the minimum distance needed for a vehicle travelling near or at the design speed for the roadway to stop for an object in its path, was measured by two field technicians. Actual sight distance limitations were measured using an eye height of 3.75 feet and an object height of 0.5 feet. Vehicle speed, roadway surface conditions, obstructions, and driver characteristics were also considered in sight distance measurement. The measurement of sight distance at intersections required the development of a minimum sight triangle, which considers unobstructed sight distance along both roads at an intersection and across the included corner.

10. Subjective Rating of Site Drivability and Physical Layout

After the field data was gathered for each site, two field technicians independently rated the drivability of the site and the completeness of the information system presented to motorists entering the site. The rating was completed on the Driver Expectancy and Information System Deficiencies forms, which are discussed in the following section of this chapter. These ratings present a relatively unbiased impression of the site layout and characteristics, since they were arrived at independently by technicians who were not familiar with the site prior to the data collection phase of the project.

11. Observation of Driver Characteristics and Quality of Travel

During the collection of field data, time was taken to observe motorists' driving habits through each site. Field observations of drivers were completed both during day and nighttime light conditions to obtain an overall impression of driver tendencies and to detect deficiencies in the overall layout of the site.

B. Analysis of Data and Calculation of Hazard Indices:

A hazard index was calculated for each site based on the following seven indicator values:

1. Number of Accidents
2. Accident Rate
3. Accident Severity
4. Volume/Capacity Ratio
5. Sight Distance
6. Driver Expectancy
7. Information System Deficiencies

For each indicator, a value between 0 and 100 was calculated, with 0 representing no hazard and 100 representing the most hazardous. The indicator values were then weighted and totalled according to accepted Department of Justice methods and values outlined in DCA Project No. 79-04-01-01 to yield the Hazard Index.

The improvement costs for each site were calculated using current construction costs and weighted against the accident reduction benefits associated with the type of improvement. In addition to the cost/benefit ratio, a cost factor was determined. The cost factor represents the improvement costs per vehicle computed by dividing the total cost for improvements at a site by the number of vehicles entering that location over a period of five years. A five-year period is used because that is the average service life of the recommended short-term improvements. The form used to compute the cost factor is shown in Figure A2 in the Appendix.

The final phase in the analysis was to determine the Priority Index (P.I.). The Priority Index is the weighted average of the Hazard Index (H.I.) and the Cost Factor (C.F.), as shown in the following equation:

$$P.I. = 0.75\ (H.I.) + 0.25\ (C.F.)$$

The site improvements were then ranked according to priority based on the Accident Hazard Indicators, Non-Accident Hazard Indicators, Cost/Benefit Ratios, Hazard Index, and Priority Index.

The following section contains a brief explanation of each of the Hazard Indicators and the Cost/Benefit Ratio.

1. Number of Accidents

Accident records for a three-year period from January, 1978 through December, 1981 were obtained from the Montana Highway Patrol. This accident data was then used to determine the three "accident" indicators (number of accidents, accident rate and accident severity). The annual average number of accidents occurring at each site was used to calculate this indicator value. Figure A3 in the Appendix shows the relationship between the annual number of accidents and the indicator value.

2. Accident Rate

This indicator is used to compensate for the wide range of traffic volumes found throughout the study sites. The average daily traffic entering each site was calculated and adjusted to represent a three-year volume. The total number of accidents per million vehicles entering the site was then calculated, resulting in the accident rate. This figure was entered into Figure A4 in the Appendix to yield the corresponding indicator value.

3. Accident Severity

This indicator evaluates the severity of the accidents occurring at each site in terms of dollars. A "Relative Severity Index" (Table A1 of the Appendix) was used to rate each accident according to accident type and to assign a corresponding accident cost. The R.S.I. values used are those in-

cluded in DCA Project No. 79-04-01-01. The average of the R.S.I. values at each site was calculated and entered into Figure A5 in the Appendix to determine the appropriate indicator value.

4. Volume-to-Capacity Ratio

The individual characteristics of the sites vary greatly. This indicator value normalizes each site with respect to lane width, geometrics, traffic mix and volume. The capacity of each site was calculated for Service Level C in accordance with the Highway Research Board, Special Report 87, Highway Capacity Manual. The volume used represents the average daily traffic entering the site. The equation used to compute the index is as follows:

$$\frac{V}{C} = \frac{ADT}{24\ (Capacity)}$$

This ratio was entered into Figure A6 (found in the Appendix) to yield the corresponding indicator value.

5. Sight Distance

The sight distance at a particular site is an excellent indicator of the hazardousness of that location. Critical sight distances were measured at each location based on the criteria outlined in the DCA Project No. 79-04-01-01. The desirable sight distances for each particular location were then calculated according to the AASHO Manual Geometric Design of Rural Highways. For each case, the ratio of the existing versus the desirable Sight Distance was calculated. The two worst cases at each site were evaluated and a weighted average was computed by assigning a weight of two to the worst rating and one to the other rating. This weighted average sight distance ratio entered into Figure A7 (found in the Appendix) yields the corresponding indicator value.

6. Driver Expectancy

The driver expectancy indicator is a purely subjective method of evaluating the ability of the average motorist to negotiate a particular section of roadway or intersection. Each site approach was rated using the criteria included on the driver expectancy form shown on Figure A8 in the Appendix. Each site was evaluated individually by two technicians and the ratings were averaged. The two approaches with the worst ratings were used in the calculation of the indicator value. A weighted average of the two ratings was calculated according to DCA weighting methods and used in Figure A9 of the Appendix to compute the corresponding indicator value.

7. Information System Deficiencies

Similar to the driver expectancy ratings, this indicator is based on the subjective judgment of the evaluator. This rating consists of evaluating the signing and striping systems at each site with respect to the systems' ability to inform and guide the motorist through a particular section of road or in-

tersection. The actual criteria used in this evaluation are shown on the rating form (Figure A10) found in the Appendix.

All site approaches were independently rated by two technicians and their ratings averaged. Only the two worst average approach ratings were actually used to calculate this indicator. A weighted average of the two ratings was computed according to the weighting formula outlined in DCA Project 79-04-01-01. This weighted average was entered into Figure A11 in the Appendix to yield the appropriate indicator value.

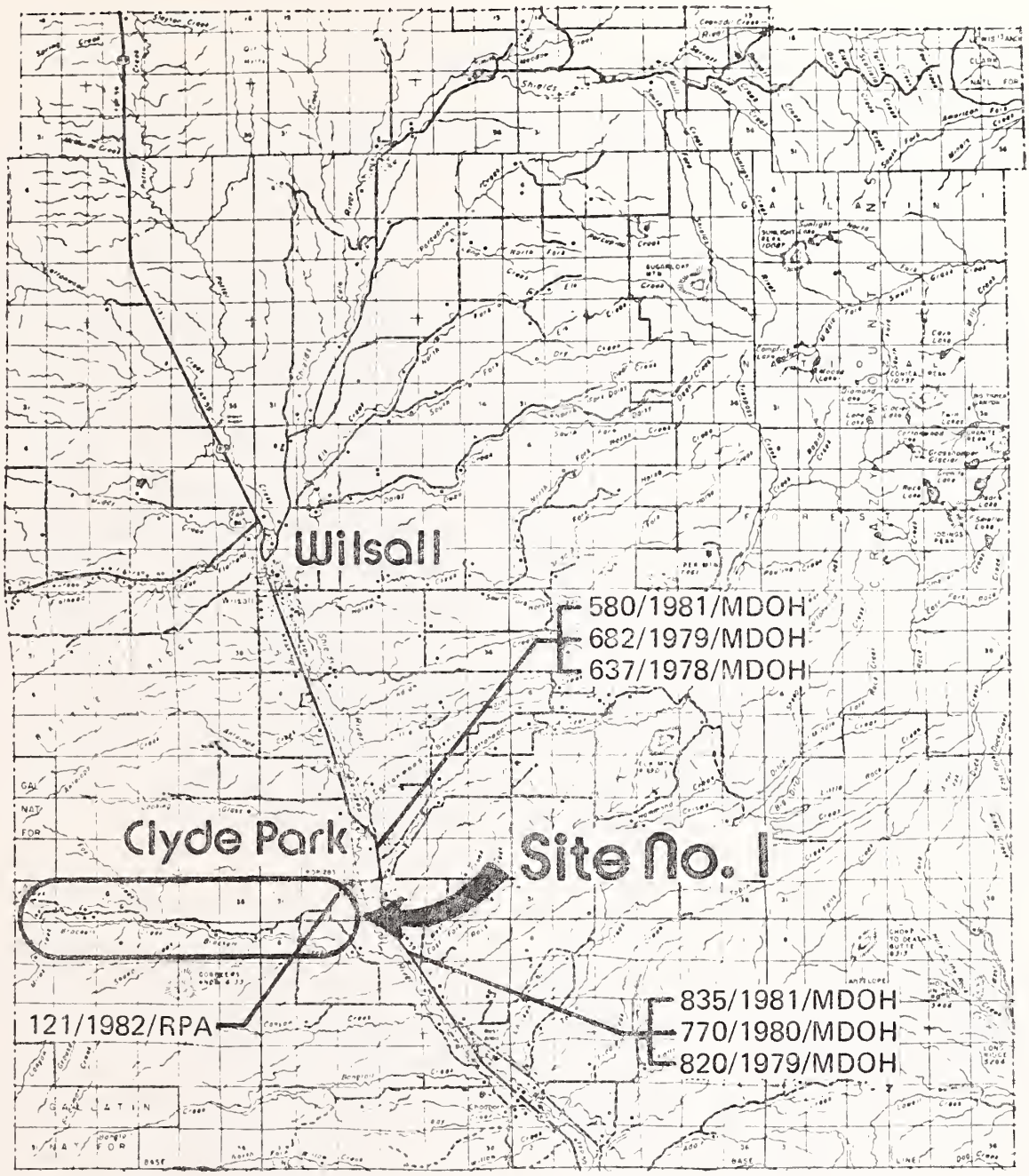
8. Benefit/Cost Ratio

Each site was analyzed and improvements were recommended. The improvement costs were estimated based on current Department of Highways statewide average construction costs. Although it is likely that Park County will implement some of the improvements with County forces, the "contracted" construction costs were used throughout for comparison purposes.

The benefits of each improvement were calculated based on the anticipated accident reduction resulting from that particular improvement. The Montana Department of Highways method for calculating the benefit/cost ratio was used and the computation format is shown in Figure A12 of the Appendix. A ranking of each site based on the benefit/cost ratio was compiled and is presented in Table 4. The site improvement yielding the greatest accident reduction benefit per dollar spent was given the highest ranking.

CHAPTER IV
SITE ANALYSIS

site no. 1



Average Daily Traffic/Year of Count/Source of Count

121/1982/RPA

SITE LOCATION
TRAFFIC COUNTS
BRACKETT CREEK ROAD

Figure No.
I-A
Park Co.

SITE #1

Brackett Creek Road

A. Location

Site #1 consists of a 4.5-mile-long section of the Brackett Creek Road which is located northwest of Clyde Park. The site begins approximately 4.8 miles west of the intersection of Brackett Creek Road and US 89 (FAP 59) at Clyde Park and ends at the Park County - Gallatin County line. The roadway is situated in a rural agricultural area in the eastern foothills of the Bridger Range. Agricultural land in the area is used mainly for pasturing livestock or raising feed or forage crops. The road is located in gently rolling terrain and parallels the winding course of Brackett Creek. The road primarily serves local traffic; however, through traffic is not uncommon, since the roadway provides access to Gallatin National Forest recreation areas including the Bridger Bowl Ski Area and to Bozeman. Due to the similar nature of the roadway, the length of the site, and number of location of accidents along this 4.5-mile section of road, this site will be discussed in general terms. The recommendations section of this analysis (Part D) will deal with specific locations along the section of Brackett Creek Road within Site #1. Figure 1A depicts the location of this site and summarizes available traffic count data.

B. Existing Conditions

Brackett Creek Road is a gravel-surfaced roadway varying in width from 24 to 40 feet. Road grades within the site vary considerably due to the rolling terrain, but typically range from 1 to 8 percent. Because of its location near the flood plain of the creek, this portion of Brackett Creek Road has no long steep grades but does have many curves around rock outcrops and along the creek. During the past year, Park County has removed major portions of the largest outcrops, thereby improving the road alignment and increasing sight distance through the curves. The road was also widened at each location to facilitate travel and snow removal. Several other locations exist where similar improvements are needed, since sight distances are restricted to less than 150 feet. In addition, much of the roadway shoulder in this site is steep and presents a hazardous driving condition to motorists.

In general, there is a lack of signing along Brackett Creek Road. There are no posted speed limit signs within the site, so the speed limit is assumed to be 55 mph. Typical site conditions are depicted in the photographs contained in Plates 1A and 1B.

Based on 24-hour machine traffic counts conducted by Robert Peccia & Associates during October, 1982, the average daily traffic (ADT) for Brackett Creek Road was determined to be 121 vehicles per day.

Existing Site Conditions

Rock outcrops at several locations along the Brackett Creek Road constitute roadside obstructions and limit sight distance.

Typical series of curves within the site. Note steep areas adjacent to the roadway and the gently rolling terrain common to the area.

Typical view of the roadway as it parallels the course of Brackett Creek.

One of several areas within the site where terrain, changes in alignment, and roadside vegetation limit sight distance.

Plate 1A

Existing Site Conditions

This curve on the Brackett Creek Road has been significantly improved by Park County.

Roadway width has been increased substantially in this area through improvements performed by the County.

Approach to a second curve where improvements were completed to increase sight distance and improve roadway alignment.

View of curve improvements from the east approach. Note the excess material placed along the outside of the curve.

Plate 1B

C. Accident History

A total of eight accidents were reported at Site #1 during the four-year study period. Two of the eight accidents resulted in injuries to a total of two persons. All eight accidents were single-vehicle accidents in which the vehicles left the roadway. In five cases, the vehicles rolled over after leaving the roadway surface. Seven of the eight accidents were classified as fixed-object collisions. The majority of the accidents occurred during the day under clear weather and dry road conditions. Only three accidents occurred at night and only two occurred during adverse road conditions. The major contributing factors in most accidents reported in this section of Brackett Creek Road appear to be reckless driving and excessive speed. The locations of the accidents at this site over the four-year study period are depicted in Figure 1B.

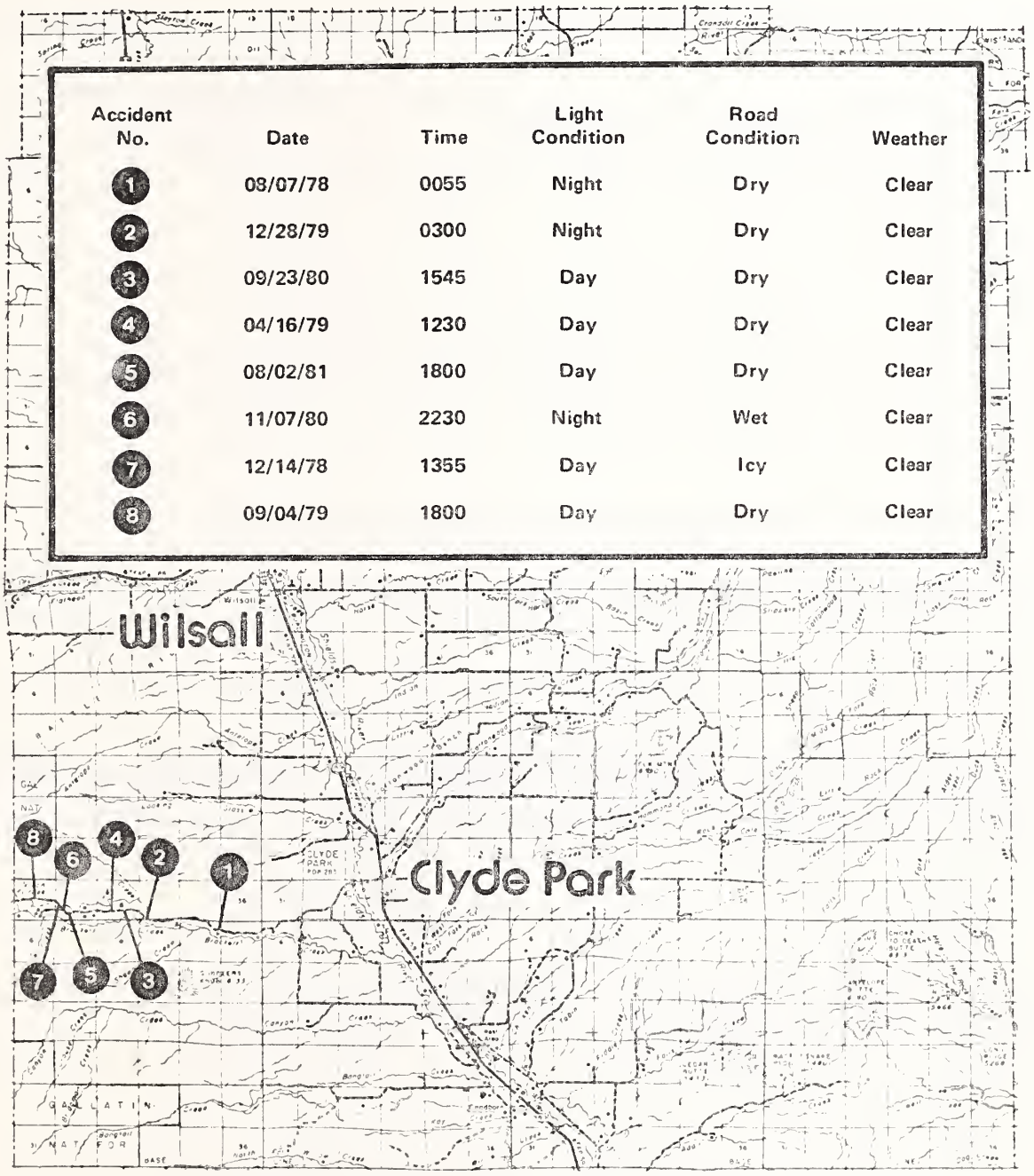
D. Recommendations

This site along Brackett Creek Road includes several curves and winding road sections. The County has recently performed some heavy spot maintenance which has greatly improved the sight distance and general driving conditions. However, there is still a need for roadway delineation and signing. According to the accident records, all of the accidents occurred as a result of vehicles leaving the road and striking a fixed object or rolling over. It is apparent that motorists either misjudge the roadway alignment or were travelling too fast to maintain control in the curves. The short-term improvements listed below concentrate on adequately signing and delineating this 4.5-mile section of Brackett Creek Road. The location of each improvement is referenced by the distance along Brackett Creek Road from US 89.

1. (4.9 miles from US 89) Park County has modified this reverse curve by removing a large volume of rock from the inside of the curve, thereby greatly increasing the available sight distance. A portion of the excavated material has been placed on the outside shoulder to help prevent vehicles from rolling over if they leave the road at this location. The County maintenance force should be commended for their excellent work at this site.

It is recommended that this reverse curve be identified by installing reverse turn warning signs (W1-3) 500 feet back from the curves on both approaches. A vehicle equipped with a ball bank indicator was used to determine that 25 mph is the maximum safe speed for these particular curves. Therefore, 25 mph advisory speed plates (W13-1) should accompany the reverse turn warning signs. Reflectorized delineators (Design C, 4" x 4", silver, bi-directional) should also be installed to identify the roadway alignment. These reflectors should be placed on the outside of each curve and should be spaced approximately 60 feet apart. Several delineators should be placed on the tangent approach sections with 125-foot spacings, thereby leading motorists into the curves. It is estimated that 16 reflectors will be required.

For more information on delineator placement and spacing, please refer to the Montana Department of Highways Standard Specifications (Signing Standard Drawing #243).



Accident No.	Date	Time	Light Condition	Road Condition	Weather
1	08/07/78	0055	Night	Dry	Clear
2	12/28/79	0300	Night	Dry	Clear
3	09/23/80	1545	Day	Dry	Clear
4	04/16/79	1230	Day	Dry	Clear
5	08/02/81	1800	Day	Dry	Clear
6	11/07/80	2230	Night	Wet	Clear
7	12/14/78	1355	Day	Icy	Clear
8	09/04/79	1800	Day	Dry	Clear

ACCIDENT LOCATIONS

BRACKETT CREEK ROAD

Figure No.
I-B
Park Co.

ACCIDENT DATA

Brackett Creek Road

SITE NUMBER 1 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

1978	1979	1980	1981
2	3	2	1

NUMBER OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
1	3	2		1	1	

NUMBER OF ACCIDENTS BY MONTH

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
			1				2	2		1	2

NUMBER OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
		1									1	1		1			2				1		1

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

Day-light	Dark	Dawn	Dusk
5	3		

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
6	1		1	

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
8			

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

Angle	Turn	Rear End	Fixed Obj.	Ped.	Animal	Side-swipe	Non-Col	Head-on	Backing
			7				1		

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Drinking	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
1		2	4					1

NUMBER OF ACCIDENTS BY SEVERITY

	1978	1979	1980	1981
Injury	1	1		
Fatality				
Property Dam. Only	1	2	2	1

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

0

2. (6.15 miles from US 89) This curve has been significantly improved by the County through rock excavation on the inside of the curve and shoulder widening. Sight distance at this location is no longer a problem. Through the use of a ball bank indicator, the appropriate speed for this curve was determined to be 25 mph. It is recommended that this curve be signed with turn warning signs (W1-1) accompanied by 25 mph advisory speed plates (W13-1). These warning signs should be located 500 feet in advance of the curve on each approach.

3. (6.9 miles from US 89) It appears that the County has already cut back the rock wall on the inside of this curve as far as economically feasible. Unfortunately, the sight distance around this curve is still somewhat restricted. A speed of 30 mph was determined to be appropriate for this site through the use of a ball bank indicator. It is recommended that turn warning signs (W1-1) with 30 mph advisory speed plates (W13-1) be installed 500 feet back from the curve on both approaches. In addition, reflectorized delineators (Design C) should be installed on the outside of the curve. Eight reflectors should be placed in the curve with a spacing of 75 feet. Two reflectors should also be placed on each approach, with a 150-foot spacing between them.

4. (7.15 miles from US 89) This curve was reconstructed by County forces in the summer of 1982. This work consisted of removing the rock outcroppings on the inside of the curve and widening the roadway shoulders in the curve. Although the physical conditions of this curve were modified and the curve consequently made safer, the maximum safe speed of this curve has been determined to be 30 mph. It is therefore recommended that turn warning signs (W1-1) with 30 mph advisory speed plates be installed on both approaches about 500 feet before the curve. A series of six reflectorized delineators (Design C) should also be installed on the outside of the curve approximately 75 feet apart. Two reflectors should be placed on each approach, and these should be spaced 150 feet apart.

5. (8.0 miles from US 89) The embankment on the inside of this curve restricts the sight distance at this site. Unfortunately, it is not feasible to alter the bank due to the irrigation ditch located directly uphill from the roadway. It is recommended that this curve be signed with turn warning signs (W1-1) located approximately 500 feet from the curve on both approaches. A ball bank indicator was used to determine that 30 mph is the maximum safe speed for this curve. Therefore, 30 mph advisory speed plates (W13-1) should be mounted with the turn warning signs. A series of reflectorized delineators (Design C) should also be installed at the site. Ten delineators will be required; six placed on the outside of the curve 75 feet apart, and two installed on each approach 150 feet apart.

6. (9.2 miles from US 89) This portion of Brackett Creek Road contains several reverse curves. The maximum safe speed for these curves was determined to be 25 mph. It is therefore recommended that winding road signs

(W1-5) with 25 mph advisory speed plates (W13-1) be installed on both approaches. These signs should be located approximately 500 feet in advance of the first curve. In addition, the alignment in this section should be identified through the use of approximately 24 reflectorized delineators (Design C). They should be placed on the outside shoulder of each curve with an approximate spacing of 60 feet. Several delineators should be placed on each approach to this section with a spacing of 125 feet. These reflectors should be placed in such a fashion as to lead motorists safely through this winding section of Brackett Creek Road.

IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
2	ea	Install Reverse Turn Warning Signs (W1-3)	$130	$ 260
8	ea	Install Turn Warning Signs (W1-1)	$130	1,040
2	ea	Install Winding Road Warning Signs (W1-5)	$130	260
6	ea	Install 25 mph Advisory Speed Plates (W13-1)	$50	300
6	ea	Install 30 mph Advisory Speed Plates (W13-1)	$50	300
72	ea	Install Reflectorized Delineators (Design C, 4" x 4", silver, bi-directional)	$18	1,296
Total Cost:				$3,456

Benefit/Cost Ratio: 1.75

Long-Term Improvements

Brackett Creek Road has been greatly improved through the efforts of the County maintenance crews. The sight distance in most of the curves has been increased by removing rock and earth from the inside of the curves and depositing it on the outside shoulders, thereby widening the travelway and actually flattening the horizontal curve alignment. This type of improvement is exactly what is required to make this section of road safer.

The long-term improvement recommended for this site is only an extension of the program already initiated by the County. All of the major curves in this site with the exception of the winding road section (9.2 miles from US 89) have been improved through the earthmoving techniques outlined above. It is recommended to address this final combination of curves in the same fashion. A portion of this section was improved by the County during the summer of 1982, when the outside shoulder of one of the curves was widened. The material on the inside of this curve, which limits sight distance around the curve, should be excavated and deposited on the south side of the road to widen the travelway. In addition, the superelevation of the curves in this particular site should be increased. These improvements will tend to straighten out the curve while increasing motorists' view of the upcoming curves. The exact superelevation required for each curve should be established in the field by an engineer after the earthmoving operation is complete.

LONG-TERM IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
2,000	cy	Excavation & Embankment, Including Reshaping the Roadway Surface	$3.50/cy	$7,000
Total Cost:				$7,000

DETERMINATION OF HAZARD INDEX

Site Number *1* Date *December, 1982*

Site Description *Brackett Creek Road*

Indicator	Data Value	Indicator Value	Weight	Partial H.I.'s
Number of Accidents	*2.0* acc/yr	*38*	x 0.164 =	*6.23*
Accident Rate	*45.3* acc/MVE	*100*	x 0.225 =	*22.50*
Accident Severity	*11,925* dollars	*67*	x 0.191 =	*12.80*
Volume/Capacity Ratio	*.13*	*31*	x 0.082 =	*2.54*
Sight Distance Ratio	*.75* (wt. avg.)	*58*	x 0.074 =	*4.29*
Driver Expectancy	*4.33* (wt. avg.)	*72*	x 0.149 =	*10.73*
Information System Deficiencies	*6.0* (wt. avg.)	*100*	x 0.115 =	*11.50*

Hazard Index: *70.59*

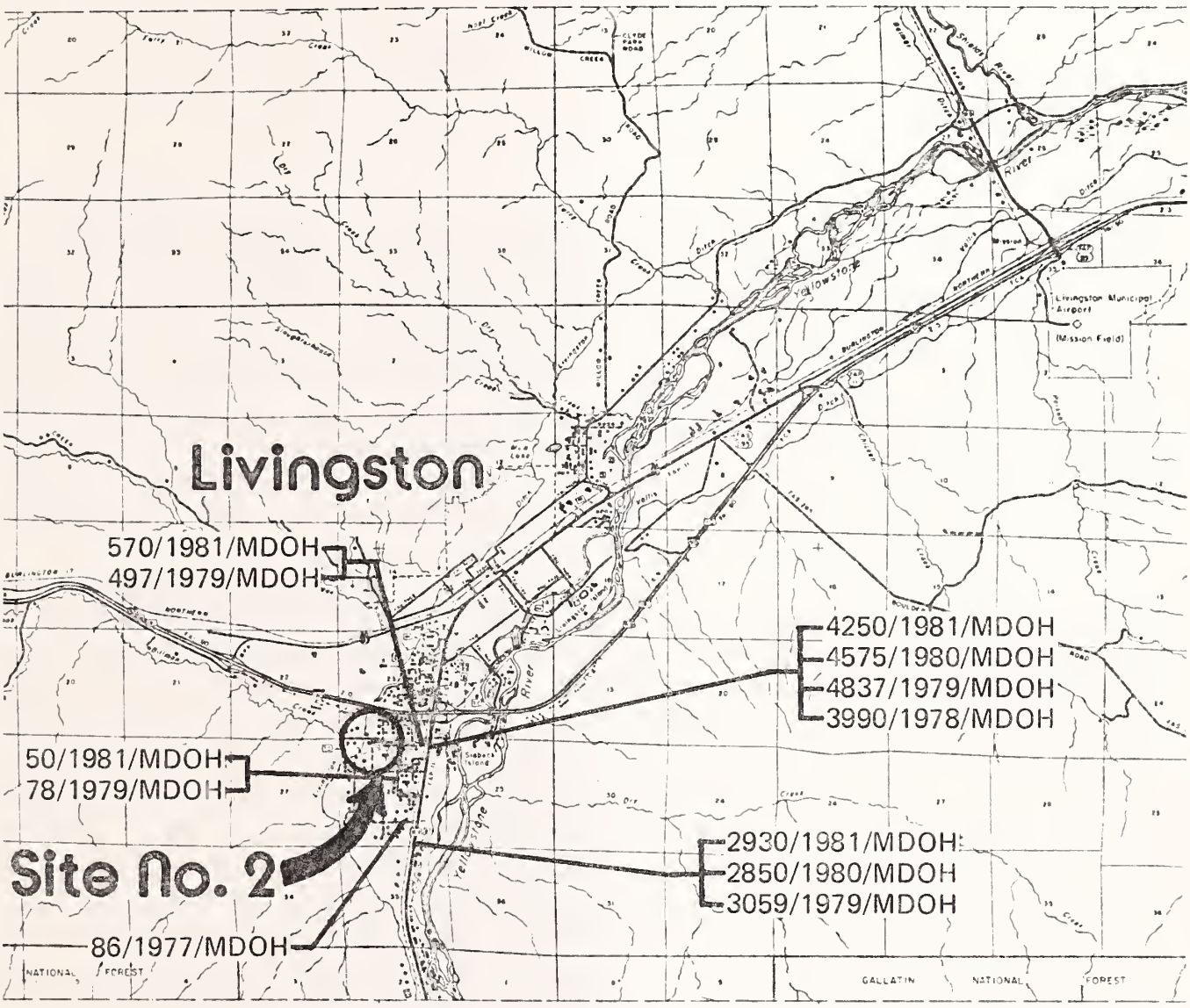
Cost of Recommended Improvements: *$3,456*

Cost Factor: *70*

Priority Index = Hazard Index x .75 + Cost Factor x .25

70.59 x .75 + *70* x .25 = *70.44*

Site no. 2



Average Daily Traffic/Year of Count/Source of Count

121/1982/RPA

SITE LOCATION
TRAFFIC COUNTS
BILLMAN CREEK LANE

Figure No.
2-A
Park Co.

SITE #2

Billman Creek Lane

A. Location

Site #2 is located in the southwestern portion of Livingston approximately .25 miles south and west of the I-90 interchange with US 89 (FAP 11). The site, which is located in a moderately developed residential area of Livingston, includes a 90-degree corner where Billman Creek Lane joins Swainson Drive and the intersection of Swainson Drive with the Windmill Park Road. The site primarily serves local residential traffic; however, during the summer months, overnight camping facilities for tourists with recreational vehicles are available at the Windmill Trailer Park. The location and existing traffic count data for Site #2 is presented in Figure 2A.

B. Existing Conditions

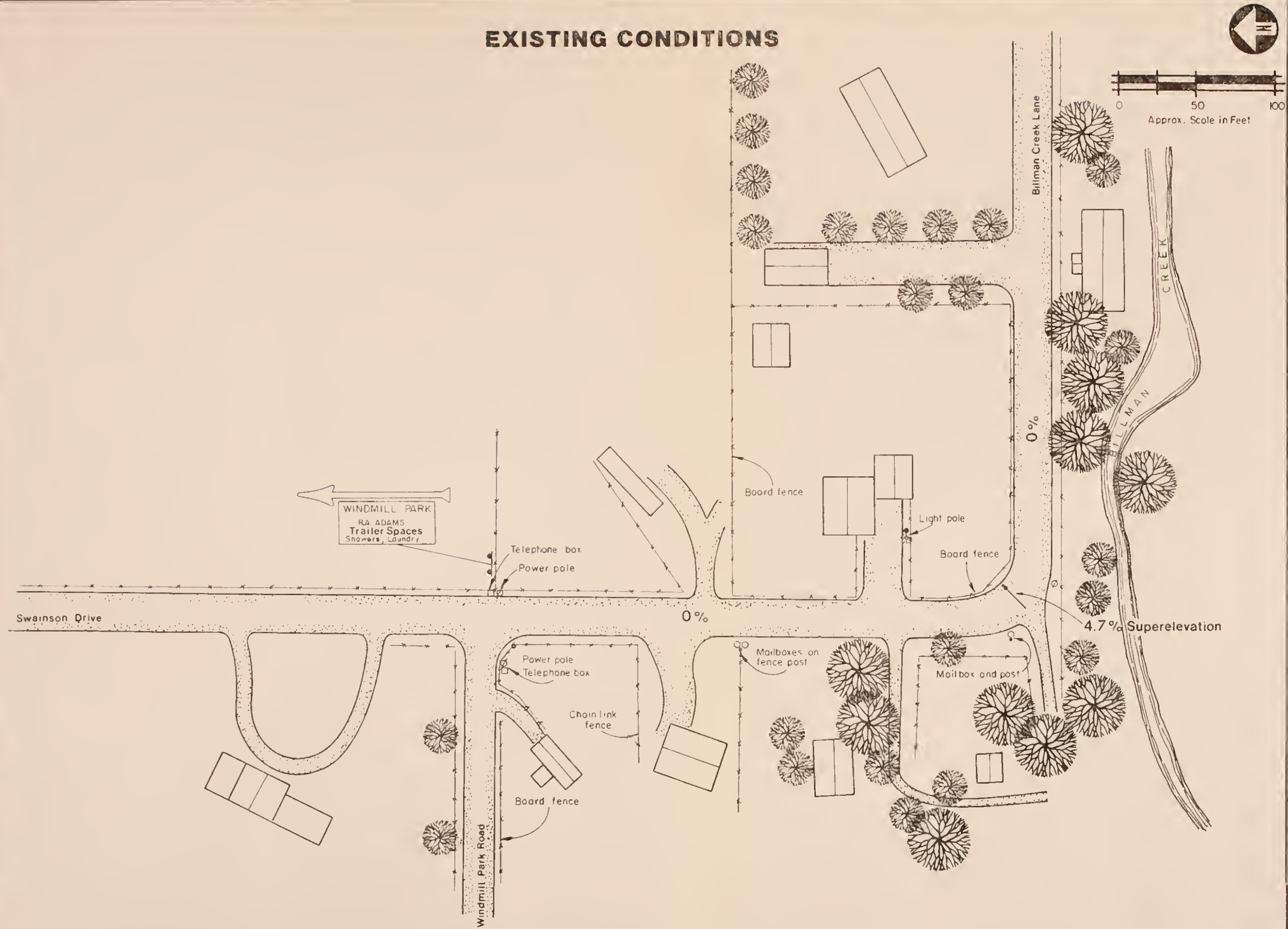
All roadways within this site are gravel surfaced with a general width of 24 feet. Although road widths are quite adequate at this site, narrow right-of-way widths tend to restrict driving maneuvers. The fence-to-fence width on both Billman Creek Lane and Swainson Drive is only 33 feet. As a result, roadside obstructions are extremely close to the lanes of travel, especially at corners where obstructions are only two feet off the edge of the roadway. Conversations with local residents confirm this assumption; several residents indicated that their fences are damaged by drivers several times each year. The narrow distance between fences also makes roadway maintenance and snow removal difficult. Road grades at the site are virtually flat. Field observations indicate that the actual travel lanes at the sharp corner and at the intersection are approximately 15 feet wide. At the present time, no signing exists within the site. A speed limit sign is located to the east of the site on Billman Creek Lane which restricts travel to 25 mph. Existing site conditions are depicted in the site sketch (Figure 2B) and in site photographs (Plate 2).

Average daily traffic for the site was determined by the Montana Department of Highways from an analysis of 24-hour machine counts on Billman Creek Lane. Traffic was determined to be 570 vehicles per day.

C. Accident History

A total of five accidents were reported at this site during the study period. None of the accidents resulted in injuries. Three of the accidents were two-car collisions including an angle collision, a rear-end collision, and a head-on collision. The other two accidents were fixed-object accidents in which vehicles struck roadside objects. Three of the five accidents occurred at the sharp corner where Billman Creek Lane joints Swainson Drive. Two of the three accidents at this location were two-car accidents that occurred on

EXISTING CONDITIONS



Site no. 2

BILLMAN CREEK LANE

Figure No.
2-B
Park Co.

Existing Site Conditions

View of east approach to site. Note the location of power poles and fence in relation to the roadway edges.

View of north approach to sharp corner at Billman Creek Lane and Swainson Drive.

Looking north along Swainson Drive. Note the proximity of fence posts to travel lanes. Actual travel lane narrows to about 15 feet through the corner.

Looking south along Swainson Drive from the intersection of the Windmill Park Road.

Plate 2

COLLISION DIAGRAM

SYMBOLS

- VEHICLE PATH
- PEDESTRIAN PATH
- BACKING VEHICLE
- PARKED VEHICLE
- FIXED OBJECT
- FATAL ACCIDENT
- INJURY ACCIDENT

COLLISION TYPES

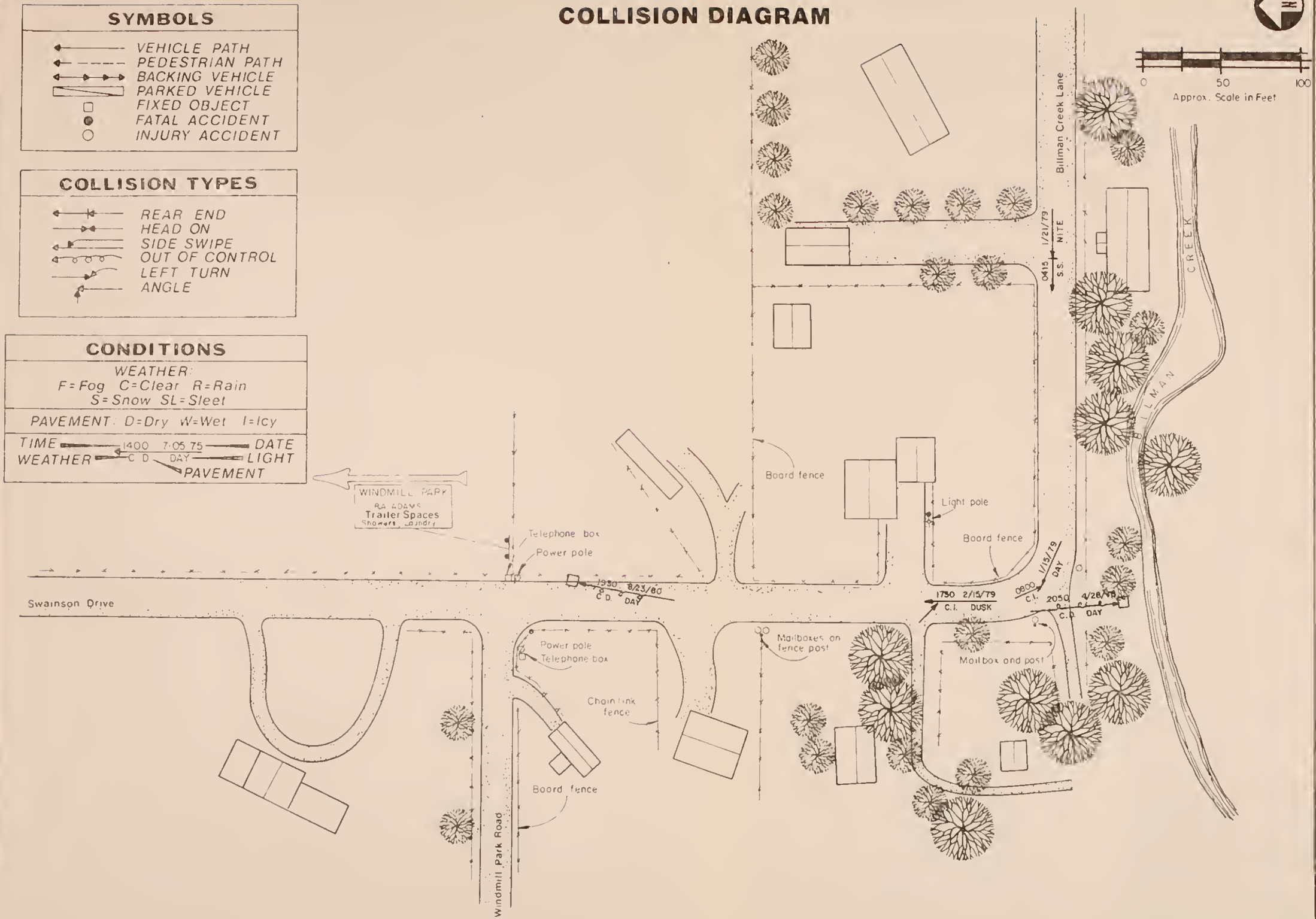
- REAR END
- HEAD ON
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- ANGLE

CONDITIONS

WEATHER:
F=Fog C=Clear R=Rain
S=Snow SL=Sleet

PAVEMENT: D=Dry W=Wet I=Icy

TIME — 1400 7-05 75 — DATE
WEATHER — C D DAY — LIGHT
PAVEMENT



Site No. 2

BILLMAN CREEK LANE

Figure No. 2-C

Park Co.

ACCIDENT DATA

Billman Creek Lane

SITE NUMBER 2 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

1978	1979	1980	1981
1	3	1	

NUMBER OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
	1			2	1	1

NUMBER OF ACCIDENTS BY MONTH

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2	1		1				1				

NUMBER OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			1				1									1		1	1				

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

Day-light	Dark	Dawn	Dusk
3	1		1

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
2		1	2	

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
4		1	

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

Angle	Turn	Rear End	Fixed Obj.	Ped.	Animal	Side-swipe	Non-Col	Head-on	Backing
1		1	2					1	

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Drinking	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
3				1	1			

NUMBER OF ACCIDENTS BY SEVERITY

	1978	1979	1980	1981
Injury				
Fatality				
Property Dam. Only	1	3	1	

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

2

slippery roads. The roadway width at the corner was also reduced due to snow banks at the road's edge. The major contributing factor to accidents at Site #2 appears to be the lack of maneuvering space in the corner and through much of the site. Alcohol was involved in two of the five accidents occurring during the study period. Figure 2C summarizes the locations and pertinent data for the accidents at this site.

D. Recommendations

Site #2 at Billman Creek Lane has a built-in hazard in the form of limited right-of-way. According to County records, road right-of-way is only 20 feet wide. Fixed objects (fences and power poles) are located immediately adjacent to the travelway, making travel during snow-packed and icy conditions very dangerous. Unfortunately, it does not appear feasible to acquire additional right-of-way in this developed area. If the County has the opportunity to purchase land adjacent to this site, it would solve many of these built-in problems.

The short-term improvements presented below concentrate on appropriately signing the site within the existing right-of-way limits.

1. The intersection of Swainson Drive and Windmill Park Lane has no signing or traffic control at this time. It is recommended that a yield sign (R1-2) be installed on the Windmill Park Lane approach. In addition to traffic control, intersection warning signs should be placed on all approaches. A "T" intersection warning sign (W2-4) should be installed on the east approach 250 feet back from the intersection. On the north and south approaches, side road warning signs (W2-2) should be used. A 250-foot setback distance should be used for the warning sign on the north approach and a distance of 200 feet on the south approach. To complete the signing of this intersection, a double directional arrow (W1-7) should be installed on the east side of the intersection. The directional arrow should be located so that it is visible for a minimum of 500 feet back on Windmill Park Lane.

2. The 90-degree bend in Billman Creek Lane presents a major problem to motorists. The curve is totally unsigned at present, and should be identified through the use of turn warning signs (W1-1) on both approaches. A ball bank indicator was used to determine that 10 mph is the maximum safe speed for this particular curve. Therefore, it is recommended that 10 mph advisory speed plates (W13-1) be posted with the turn warning signs. These signs should be located far enough in advance of the curve to allow enough time for motorists to react. For this particular situation, a setback distance of 200 feet is recommended for turn warning signs. Typically, the signs should be placed farther back from curves, but due to the location of the adjacent intersections and the relatively slow vehicle speeds in this residential area, 200 feet is appropriate. Directional arrows (W1-6) should be placed on the outside of the curve to properly locate the bend and reinforce the advance turn warning signs. The directional arrows should be placed so they are visible for at least 500 feet on each approach. The appropriate location of these arrows is depicted on Figure 2D.

3. Due to the sharp bend in Billman Creek Lane, vehicles tend to drive only on the inside lane around the curve. The outside lane is heavily graveled, so motorists seem to avoid it. The apparent travelway width in the curve is only 15 feet; the additional roadway width is not being used by motorists. One head-on collision at this location appears to be partially due to this situation. The abnormally heavy amounts of loose gravel in the outside lane should not be allowed to accumulate, and should be cleared periodically by County maintenance crews. This practice will allow motorists to utilize the entire roadway width in this curve.

4. Heavy snow conditions at this site become a major problem because the narrow right-of-way widths limit snow storage adjacent to the road. Caution should be used when plowing to insure that snow berms do not block motorists' view of the other approaches at this site. In particular, snow accumulation on the inside of the 90-degree bend on Billman Creek Lane should be removed to permit a clear view of any oncoming traffic. In addition, snow should be plowed or removed from the site in such a way that a minimum travel width of 20 feet is maintained.

IMPROVEMENT COST ESTIMATE

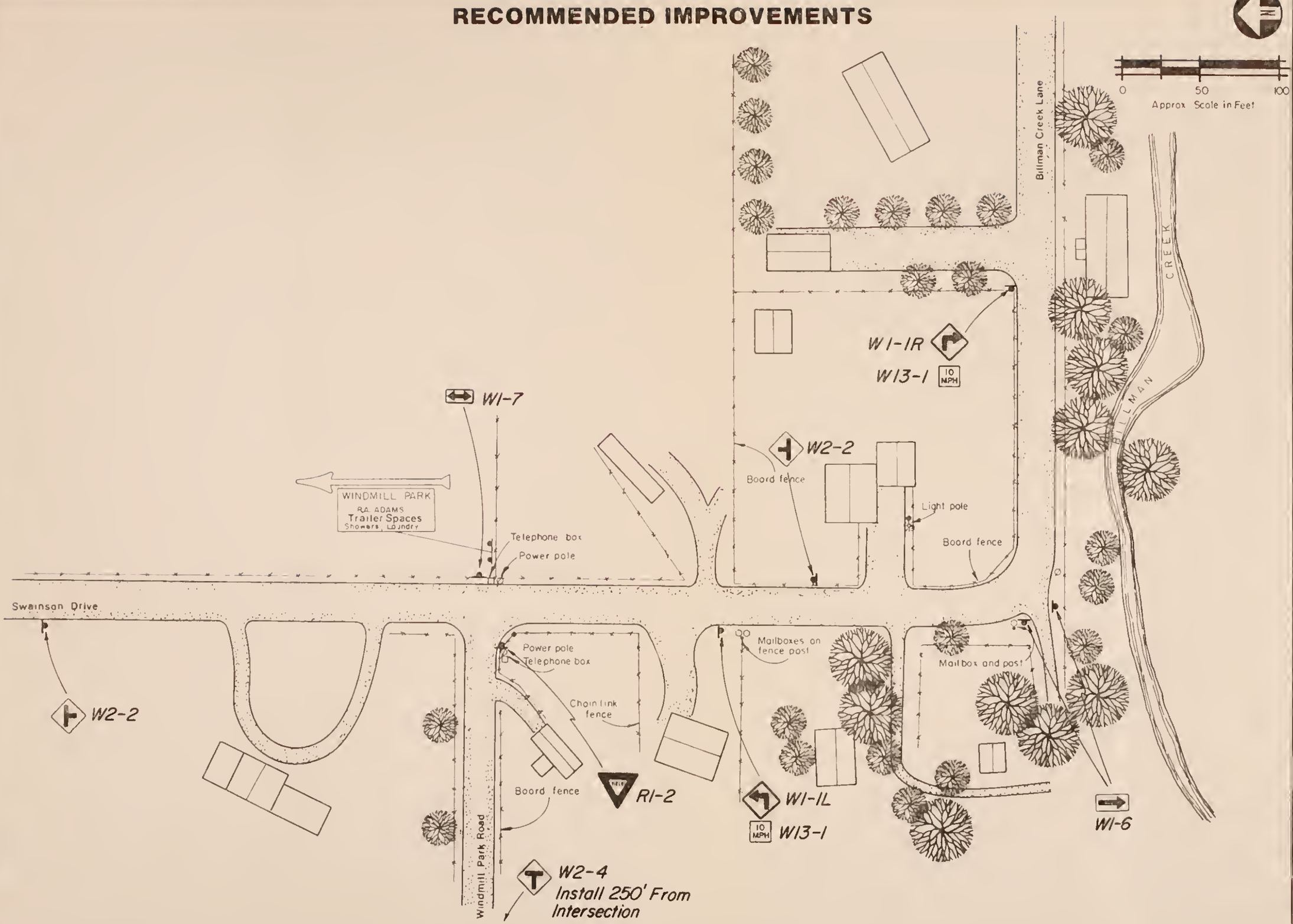
Quantity	Unit	Item Description	Unit Price	Total Price
1	ea	Install Yield Sign (R1-2)	$130	$130
1	ea	Install "T" Intersection Warning Sign (W2-4)	$130	130
2	ea	Install Side Road Warning Sign (W2-2)	$130	260
1	ea	Install Double Directional Arrow (W1-7)	$163	163
2	ea	Install Directional Arrows (W1-6)	$163	326
2	ea	Install Turn Warning Signs (W1-1) with 10 mph Advisory Speed Plates (W13-1)	$180	360
Total Cost:				$1,369

Benefit/Cost Ratio: 1.0

Long-Term Improvements

The signing improvements outlined herein have adequately addressed the problems related to this site; therefore, no long-term improvements are recommended.

RECOMMENDED IMPROVEMENTS



Site No. 2

BILLMAN CREEK LANE

Figure No.
2-D
Park Co.

DETERMINATION OF HAZARD INDEX

Site Number *2* Date *December, 1982*

Site Description *Billman Creek Lane*

Indicator	Data Value	Indicator Value	Weight	Partial H.I.'s
Number of Accidents	*1.25* acc/yr	*30*	x 0.164 =	*4.92*
Accident Rate	*6.5* acc/MVE	*81*	x 0.225 =	*18.23*
Accident Severity	*4,880* dollars	*46*	x 0.191 =	*8.79*
Volume/Capacity Ratio	*.60*	*100*	x 0.082 =	*8.2*
Sight Distance Ratio	*.81* (wt. avg.)	*39*	x 0.074 =	*2.89*
Driver Expectancy	*4.8* (wt. avg.)	*80*	x 0.149 =	*11.92*
Information System Deficiencies	*6.0* (wt. avg.)	*100*	x 0.115 =	*11.5*

Hazard Index: *66.45*

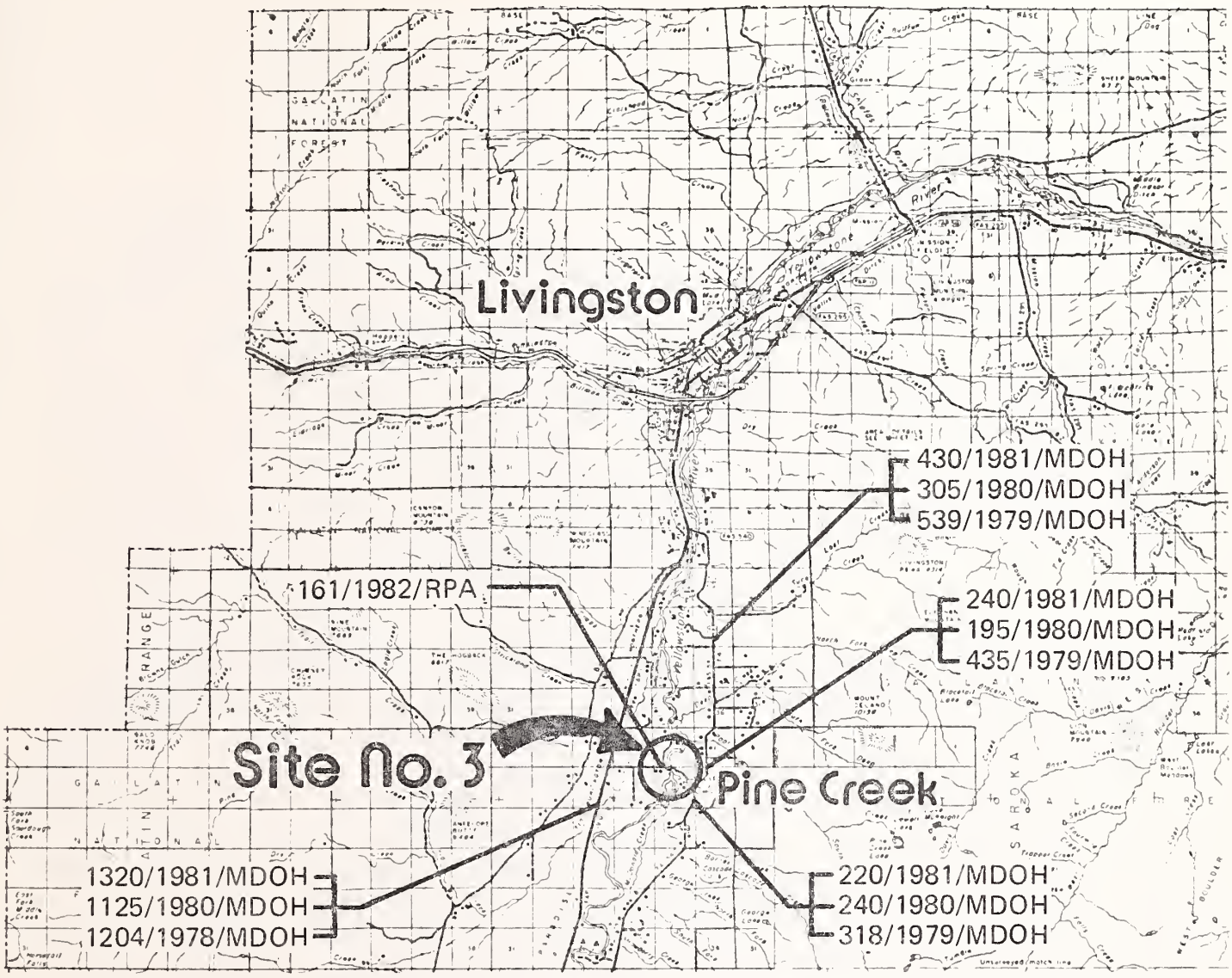
Cost of Recommended Improvements: *$1,369*

Cost Factor: *99*

Priority Index = Hazard Index x .75 + Cost Factor x .25

66.45 x .75 + *99* x .25 = *74.59*

Site No. 3



Average Daily Traffic/Year of Count/Source of Count

121/1982/RPA

SITE LOCATION
TRAFFIC COUNTS
PINE CREEK BRIDGE

Figure No.
3-A
Park Co.

SITE #3

Pine Creek Bridge over the Yellowstone River

A. Location

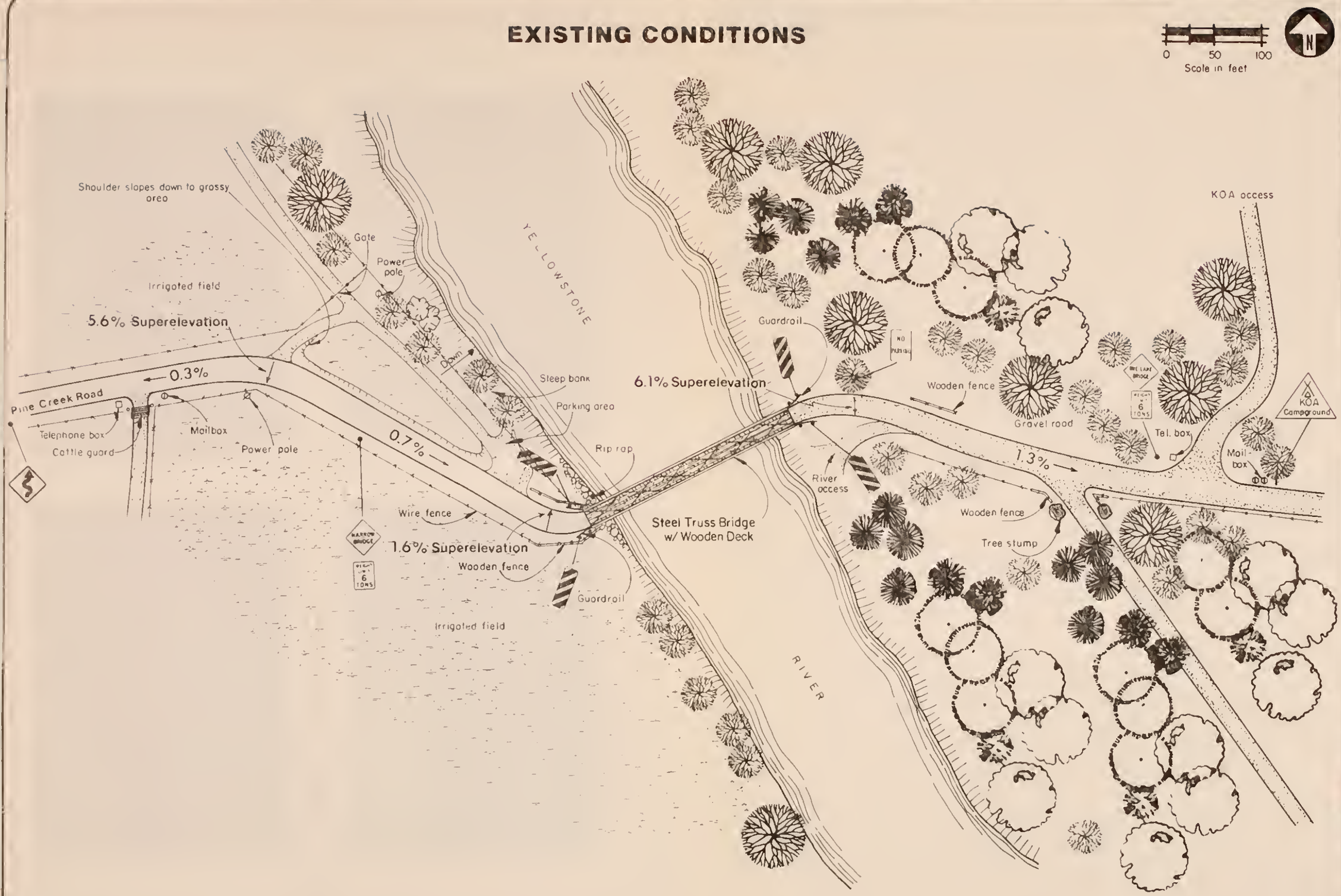
Site #3 is located approximately 12.5 miles south of Livingston near the community of Pine Creek. The site consists of the Yellowstone River Bridge and the east and west approaches to the bridge. The land on the west side of the river is primarily used as pasture for livestock, and land to the east of the river is moderately developed with seasonal campground facilities and homesites. The roadway provides the most direct access to US 89 (FAP 11) for residents of the Pine Creek area. Access to numerous campgrounds and recreation areas in the Gallatin National Forest is also provided by the roadway that passes through Site #3. The location and available traffic count data for this location is presented in Figure 3A.

B. Existing Conditions

The west approach to the Yellowstone River Bridge at Pine Creek is an asphalt-surfaced roadway 20 feet in width. The pavement surface is unstriped and in poor condition, especially in the curve at the west end of the bridge. Road grades on this approach are relatively flat, ranging from 0.3 to 0.7 percent. Superelevations on the west approach appear adequate, except in the sharp curve adjacent to the bridge. The superelevation at this point is less than 2 percent, which hinders the movement of vehicles heading onto the bridge. Signing on the west approach consists of a winding road warning sign (W1-5R) located approximately 275 feet before the first curve; a narrow bridge warning sign (W5-2) and a weight limit sign (R12-1) located 250 feet from the bridge; and object markers (OM-3) installed at the bridge approach. There are no speed limit signs within this approach to the site. Ball bank tests indicated that the correct speed for the curve near the bridge is 15 mph.

The bridge itself is a steel truss structure built in 1910 that is 16 feet wide from railing to railing and 235 feet long. It is constructed of untreated timber with timber running boards identifying the lane of travel. The Montana Department of Highways Bridge Evaluation Bureau inspected the structure during February of 1982, and rated its condition as "fair". Safety features of the bridge were listed as "poor" due to the need for a more effective deck railing and for the extension of approach railings at both ends of the structure. The most notable accident in recent years at the Pine Creek Bridge occurred during May, 1979 when a heavily loaded gravel truck fell through the deck into the river, injuring the driver. In May, 1982 the Park County Commissioners determined that the Pine Creek Bridge is the first priority for bridge replacement in the County.

EXISTING CONDITIONS

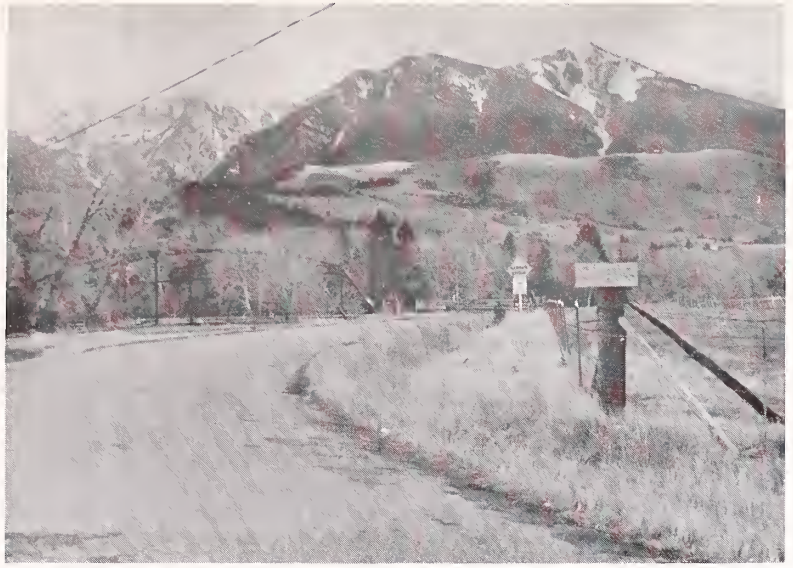


Site No. 3 PINE CREEK BRIDGE

Figure No. 3-B

Park Co.

Existing Site Conditions



View of west approach to the Pine Creek Bridge. Note change in road alignment and signing.

View of existing conditions at the west end of the bridge. Note the deteriorated pavement condition and flat superelevation at this location.

View of the east approach to the bridge. Note steep area adjacent to roadway near the bridge.

Looking westward across the Pine Creek Bridge. The bridge, built in 1910, is 16 feet wide and 235 feet long.

Plate 3

The east approach to the Pine Creek Bridge is a gravel-surfaced roadway 22 feet wide. The grade on this approach to the bridge is approximately 1.5 percent. The 6 percent superelevation in the curve nearest the bridge on the east approach is appropriate for the average travel speeds at this site. Signing on the east approach includes a one-lane bridge sign (W5-3) and a weight limit sign (R12-1) located 410 feet from the bridge; a no parking sign (R8-3) located near the bridge; and object markers (OM-3) located at the end of the approach railing. There are no speed limit signs on the east approach to this bridge.

Based on machine counts of 24-hour traffic volumes conducted during October, 1982 by Robert Peccia & Associates, average daily traffic on the Pine Creek Road was determined to be 161 vehicles per day. Traffic volumes are expected to be higher during the summer due to the amount of recreational traffic generated by the KOA Campground and Forest Service facilities in the area. Existing site conditions are depicted in Figure 3B and in Plate 3.

C. Accident History

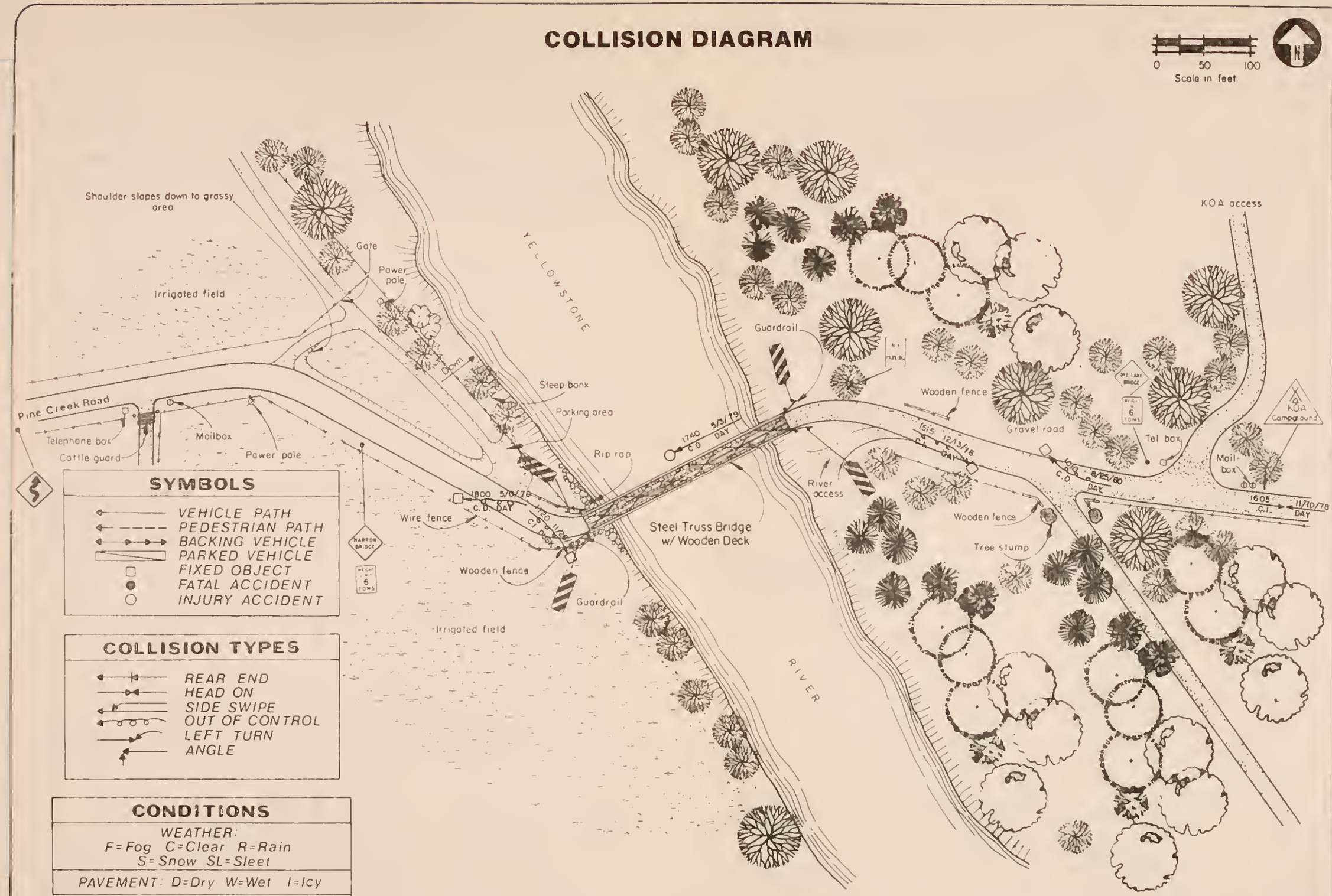
Six accidents were reported at Site #3 during the four-year study period, with only one injury resulting. This injury occurred during the previously mentioned gravel truck accident. Only one of the six accidents was a two-vehicle collision; the remainder were fixed-object collisions. All six accidents occurred under daylight or dusk conditions during clear weather. Three of the accidents occurred when the bridge approaches were icy. Most of the accidents at the site were the result of excess speed for conditions at the site or reckless driving; alcohol was involved in one of the six accidents. The composite collision diagram for the reported accidents at the site is depicted in Figure 3C.

D. Recommendations

Both the sharp curves and the long, one-lane bridge at this site present serious driving hazards. The optimum solution at this location is to reconstruct and realign the bridge, thereby eliminating the curves. The short-term improvements outlined below attempt to improve the existing road alignment and bridge through appropriate signing and delineation techniques.

1. Accident records indicate that motorists have difficulty identifying the alignment of the road through this site. The winding road warning sign located on the west approach is the only signing that aids motorists in negotiating this site. Additional signing and delineation should be installed to more effectively identify the roadway alignment. A series of ten reflectorized delineators should be installed on the outside of the wide curve on the west approach to the bridge. These reflectors (Design C, 4" x 4", silver, bi-directional) should be spaced through the curve and on the curve approaches as indicated on Figure 3D. Note that an increased spacing is used on the approaches, thereby leading motorists through the curve.

COLLISION DIAGRAM



SYMBOLS

- VEHICLE PATH
- PEDESTRIAN PATH
- BACKING VEHICLE
- PARKED VEHICLE
- FIXED OBJECT
- FATAL ACCIDENT
- INJURY ACCIDENT

COLLISION TYPES

- REAR END
- HEAD ON
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- ANGLE

CONDITIONS

WEATHER:
F=Fog C=Clear R=Rain
S=Snow SL=Sleet

PAVEMENT: D=Dry W=Wet I=Icy

TIME — 1400 7-05-75 — DATE
WEATHER — C D DAY — LIGHT
PAVEMENT

Site No. 3 PINE CREEK BRIDGE

Figure No. 3-C

Park Co.

ACCIDENT DATA

Pine Creek Bridge

SITE NUMBER 3 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

1978	1979	1980	1981
3	2	1	

NUMBER OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
2	1		1	1	1	

NUMBER OF ACCIDENTS BY MONTH

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
				2			1			2	1

NUMBER OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
									1					1	1	2	1						

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

Day-light	Dark	Dawn	Dusk
5			1

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
3			3	

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
6			

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

Angle	Turn	Rear End	Fixed Obj.	Ped.	Animal	Side-swipe	Non-Col	Head-on	Backing
			4				1	1	

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Drinking	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
2		1	3					

NUMBER OF ACCIDENTS BY SEVERITY

	1978	1979	1980	1981
Injury		1		
Fatality				
Property Dam. Only	3	1	1	

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

1

2. To emphasize the sharp turn on the west bridge approach, it is recommended that a turn warning sign (W1-1) be installed 250 feet back from the beginning of the curve. Through the use of a ball bank indicator, the maximum safe speed for this curve was determined to be 15 mph. Therefore, a 15 mph advisory speed plate (W13-1) should accompany the turn warning sign. Due to the generally slow vehicle speeds on the bridge itself, no turn warning or advisory speed plate is required for westbound traffic.

In addition to the advance warning sign, two directional arrows (W1-6) should be installed in the curve. Each arrow sign should be located to be visible for 500 feet on each approach.

3. The narrow bridge warning sign and the weight limit sign posted on the west approach should be removed. Likewise, the single-lane bridge warning sign and the weight limit sign on the east approach should also be removed. It is always considered poor signing practice to present two signs on the same post, with the exception of supplementary advisory plates. In this particular case, a warning sign is being presented with a regulatory sign. This may cause motorists to be confused or only read one of the two messages. The weight limit regulatory signs (R12-1) should be located immediately adjacent to the end of the bridge on both approaches. The most appropriate warning sign in this situation is the one-lane bridge warning sign (W5-3). These warning signs should be installed approximately 250 feet in advance of the bridge on both approaches.

4. The sharp curve on the east bridge approach should be identified. It is recommended that a pair of directional arrows (W1-6) be placed in the curve. These warning signs should be located so the motorist can clearly see them for 500 feet back on each approach.

5. A reverse turn warning sign (W1-3) should be installed on the east approach to this site. A 15 mph advisory speed plate (W13-1) should be posted along with this warning sign. Motorists will thereby be forewarned of the series of sharp curves ahead. The signs should be located 500 feet east of the first curve to allow motorists enough time to react to the upcoming situation.

IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
10	ea	Install Reflectorized Delineators (Design C, 4" x 4")	$18	$180
1	ea	Install Turn Warning Sign (W1-1) with 15 mph Advisory Speed Plate (W13-1)	$180	180

Quantity	Unit	Item Description	Unit Price	Total Price
4	ea	Install Directional Arrows (W1-6)	$163	$652
1	ea	Remove Narrow Bridge Sign	$35	35
2	ea	Relocate Weight Limit Sign (R12-1)	$105	210
1	ea	Relocate One-Lane Bridge Warning Sign (W5-3)	$105	105
1	ea	Install One-Lane Bridge Warning Sign (W5-3)	$130	130
1	ea	Install Reverse Turn Warning Sign (W1-3) with 15 mph Advisory Speed Plate (W13-1)	$180	180
Total Cost:				$1,652

Benefit/Cost Ratio: 1.0

Long-Term Improvements

The sharp curve adjacent to the west end of the bridge has a superelevation of 1.6 percent, which is too flat for the tight radius of this curve. The present geometrics tend to force vehicles to the outside of the curve, creating a hazardous situation. The pavement in this curve is also deteriorated. It is recommended that the superelevation grade be altered when the road is resurfaced. The superelevation should be increased to approximately 6 percent to provide a smoother ride and a safer curve.

There is a steep drop-off on both sides of the road adjacent to the curve on the east approach. It is recommended that 150 feet of guard rail be installed on the outside of the curve and 100 feet on the inside. These guard rail sections will prevent vehicles from leaving the road on this approach, thereby minimizing the severity of accidents.

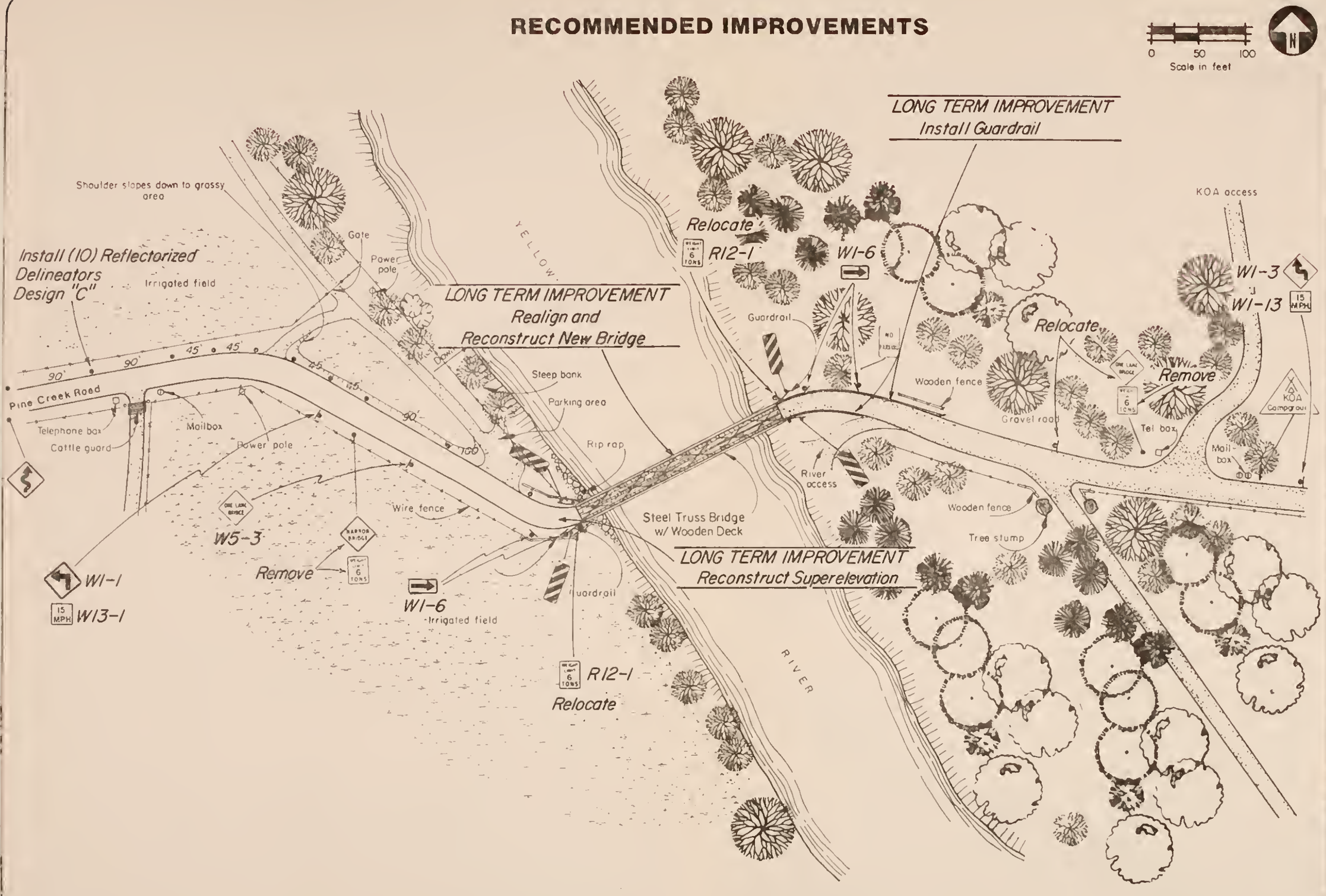
The optimum solution for this site is to remove the existing bridge and replace it with a new structure. The new bridge should accommodate two-way traffic, and should be realigned to eliminate the curves at this site. Due to the complexity and magnitude of this improvement, only a general cost range of $800,000 to $1,000,000 is presented. Considering the estimated cost of this improvement and the limitations on County funds, it is likely that this improvement could only be undertaken with the assistance of alternate funding sources. Unfortunately, it does not appear that funding will be available for this improvement in the near future.

LONG-TERM IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
-	Lump Sum	Reconstruct Superelevation	-	$4,000
250	lf	Install Guard Rail	$9	2,250
Total Cost*				$6,250

* Estimate does not include cost of bridge reconstruction

RECOMMENDED IMPROVEMENTS



3 PINE CREEK BRIDGE

Site no. 2

Figure No.
3-D
Park Co.

DETERMINATION OF HAZARD INDEX

Site Number *3* Date *December, 1982*

Site Description *Pine Creek Bridge*

Indicator	Data Value	Indicator Value	Weight	Partial H.I.'s
Number of Accidents	*1.5* acc/yr	*33*	x 0.164 =	*5.41*
Accident Rate	*25.5* acc/MVE	*100*	x 0.225 =	*22.5*
Accident Severity	*12,650* dollars	*70*	x 0.191 =	*13.37*
Volume/Capacity Ratio	*.23*	*40*	x 0.082 =	*3.28*
Sight Distance Ratio	*1.10* (wt. avg.)	*26*	x 0.074 =	*1.92*
Driver Expectancy	*5.2* (wt. avg.)	*87*	x 0.149 =	*12.96*
Information System Deficiencies	*4.8* (wt. avg.)	*80*	x 0.115 =	*9.20*

Hazard Index: *68.64*

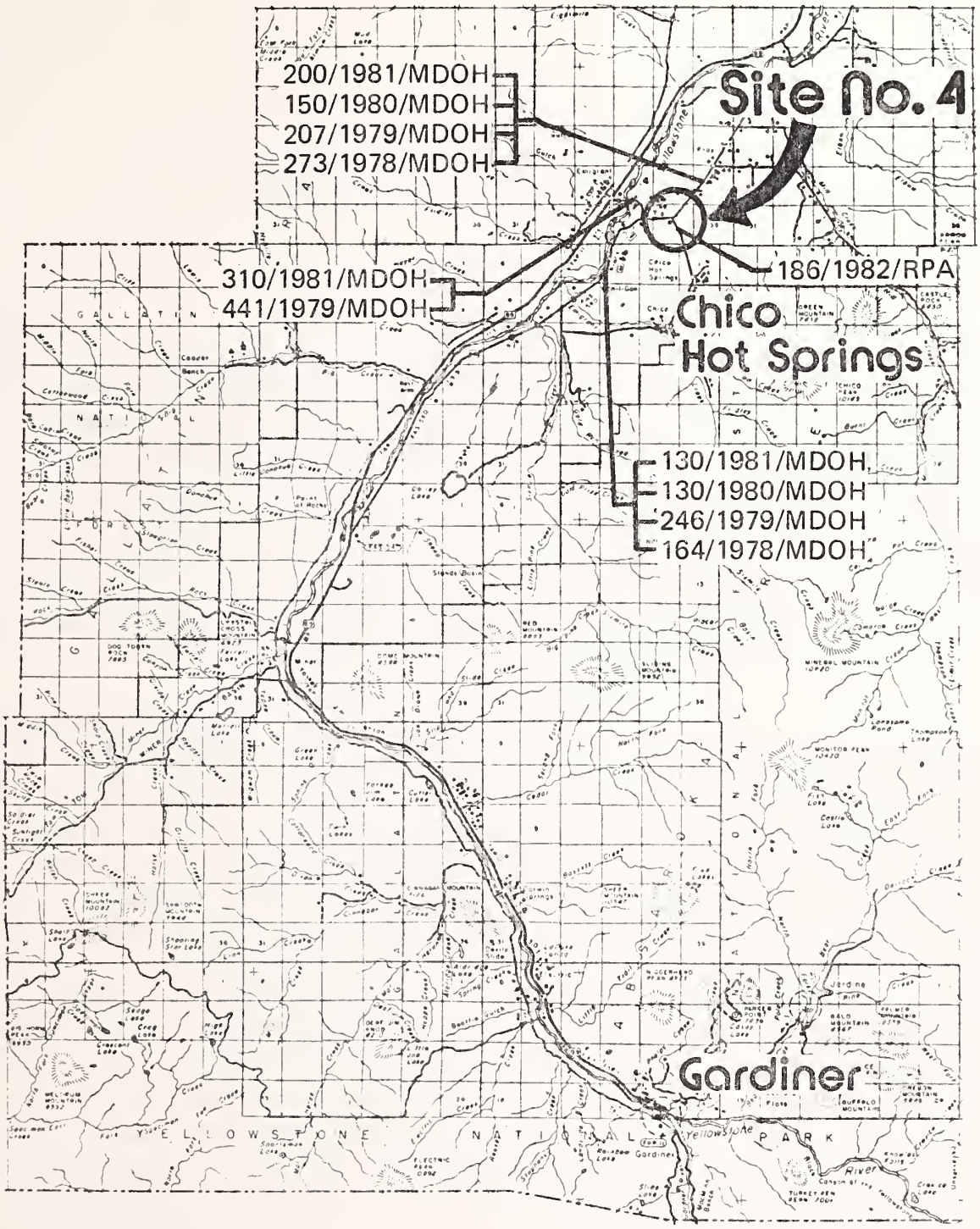
Cost of Recommended Improvements: *$1,652*

Cost Factor: *90*

Priority Index = Hazard Index x .75 + Cost Factor x .25

68.64 x .75 + *90* x .25 = *73.98*

Site no.4



Average Daily Traffic/Year of Count/Source of Count

121/1982/RPA

SITE LOCATION
TRAFFIC COUNTS
CHICO HOT SPRINGS ROAD

Figure No. 4-A

Park Co.

SITE #4

Intersection of East River Road (FAS 540) and Chico Hot Springs Road

A. Location

Site #4 is located approximately 1.8 miles east of Emigrant and includes the intersection of East River Road (FAS 540) and the Chico Hot Springs Road. The site is located approximately 23 miles south of Livingston in the gently rolling terrain near the base of the Absaroka Range. Both roadways serve local residents as well as large numbers of recreational visitors utilizing federal, state and private recreation sites in the area. In addition to recreational traffic at this site, substantial local traffic is generated by a solid waste container site located at the intersection. The location of Site #4 and the existing traffic count data for area roadways is summarized in Figure 4A.

B. Existing Conditions

East River Road is an asphalt-surfaced roadway which is typically 20 feet wide with pavement striping delineating two 10-foot driving lanes. Pavement condition on this roadway is in severely deteriorated condition and results in somewhat hazardous driving conditions. Road grades on East River Road are 4 percent north of the intersection, 1.3 percent at the intersection, and 4.2 percent on the south approach. All grades fall to the south at this location. The broad curve at the site has an effective superelevation of nearly 6 percent. Signing on the north approach to the intersection consists of a curve warning sign (W1-2R) located 1,100 feet from the intersection and a side road warning sign (W2-2) located 790 feet from the intersection. Signing on the south approach is similar; however, the side road sign is located 450 feet from the intersection due to a change in grade which slightly limits sight distance. The sight distance is limited to approximately 270 feet north of the intersection at the crest in the grade running north-south through the site. Reflectorized delineators have also been used on the south approach, primarily to identify culverts.

The east leg of the intersection is a 30-foot-wide paved surface roadway which is striped to delineate two 12-foot driving lanes and 3-foot shoulders. The long, straight roadway has a general grade of approximately 2.5 percent toward the intersection. Signing on the Chico Hot Springs Road advises motorists of the approaching intersection and consists of a secondary route marker (M1-8) and junction plaque (M2-1) located 1,425 feet from the intersection; an oversized stop ahead sign (W3-1) located 550 feet from the intersection; and a stop sign located at the intersection. In addition to this signing, advance pavement word markings denoting "Stop Ahead" are located on the east approach. The speed limit on all legs of the intersection is 55

EXISTING CONDITIONS

EAST RIVER ROAD AT CHICO HOT SPRINGS RD.

Site No. 4

Figure No.
4-B
Park Co.

Existing Site Conditions

View of north approach to the intersection. Note pavement condition and existing signing.

View of the intersection of the Chico Hot Springs Road and the East River Road.

View of southern approach to the intersection. Slight grade at this location makes identification of the intersection difficult.

View of east approach to the intersection. Travel speeds on this approach are quite high due to the good condition of the roadway surface and the alignment.

Plate 4

mph. Existing conditions at this site are depicted in Figure 3B and in Plate 3.

Based on machine counts of 24-hour traffic volumes conducted by Robert Peccia & Associates and the Montana Department of Highways, average daily traffic (ADT) for the East River Road near the site was determined to be 200 vehicles per day, and on the Chico Hot Springs Road was determined to be 186 vehicles per day.

C. Accident History

A total of two accidents were reported at this site during the four-year study period extending from January, 1978 through December, 1981. The accidents resulted in injuries to a total of two persons. In addition to the reported accidents, local officials and residents have indicated that many more accidents have occurred at this intersection over the years that have gone unreported. Most of these accidents have occurred when vehicles approaching the intersection on Chico Hot Springs Road were unable to stop and slid through the intersection. The fence on the west side of this intersection has been repaired many times, and black and white striped dead end barricade markers have been installed to identify the fence. Both reported accidents at this site involved single vehicles which left the roadway and rolled over. Both accidents occurred at night under clear and dry weather and road conditions, and alcohol was involved in both accidents. The composite collision diagram for the accidents at this site is depicted in Figure 4C.

D. Recommendations

The intersection at Site #4 has a variety of existing signing and pavement markings, including advance warning signs on all approaches. The west intersection approaches on River Road are effectively signed, and do not require modification. Unfortunately, motorists on the east approach still miss this intersection, run the stop sign, and end up in the field to the west. This situation continues despite the County's signing efforts, since the long tangent approach to this intersection from the east is largely to blame. Motorists are "lulled to sleep" by the monotonous drive from Chico to the intersection. The short-term improvements outlined below are intended to alert motorists to the intersection and hopefully minimize accidents at this site.

1. The use of pavement markings is a very effective means of alerting motorists to upcoming situations. However, at the time of the field investigation, the pavement markings on the east approach were so badly worn that they were ineffective. It is recommended that these pavement markings be maintained in good visible condition at all times. In addition, a painted stop bar should be installed adjacent to the stop sign to further emphasize the stop condition on the east approach.

2. The existing stop sign should be removed and replaced with an oversized 48" x 48" stop sign (R1-1). This large sign will help identify the location of the intersection and will be clearly visible far in advance on the approach.

SYMBOLS

- VEHICLE PATH
- PEDESTRIAN PATH
- BACKING VEHICLE
- PARKED VEHICLE
- FIXED OBJECT
- FATAL ACCIDENT
- INJURY ACCIDENT

COLLISION TYPES

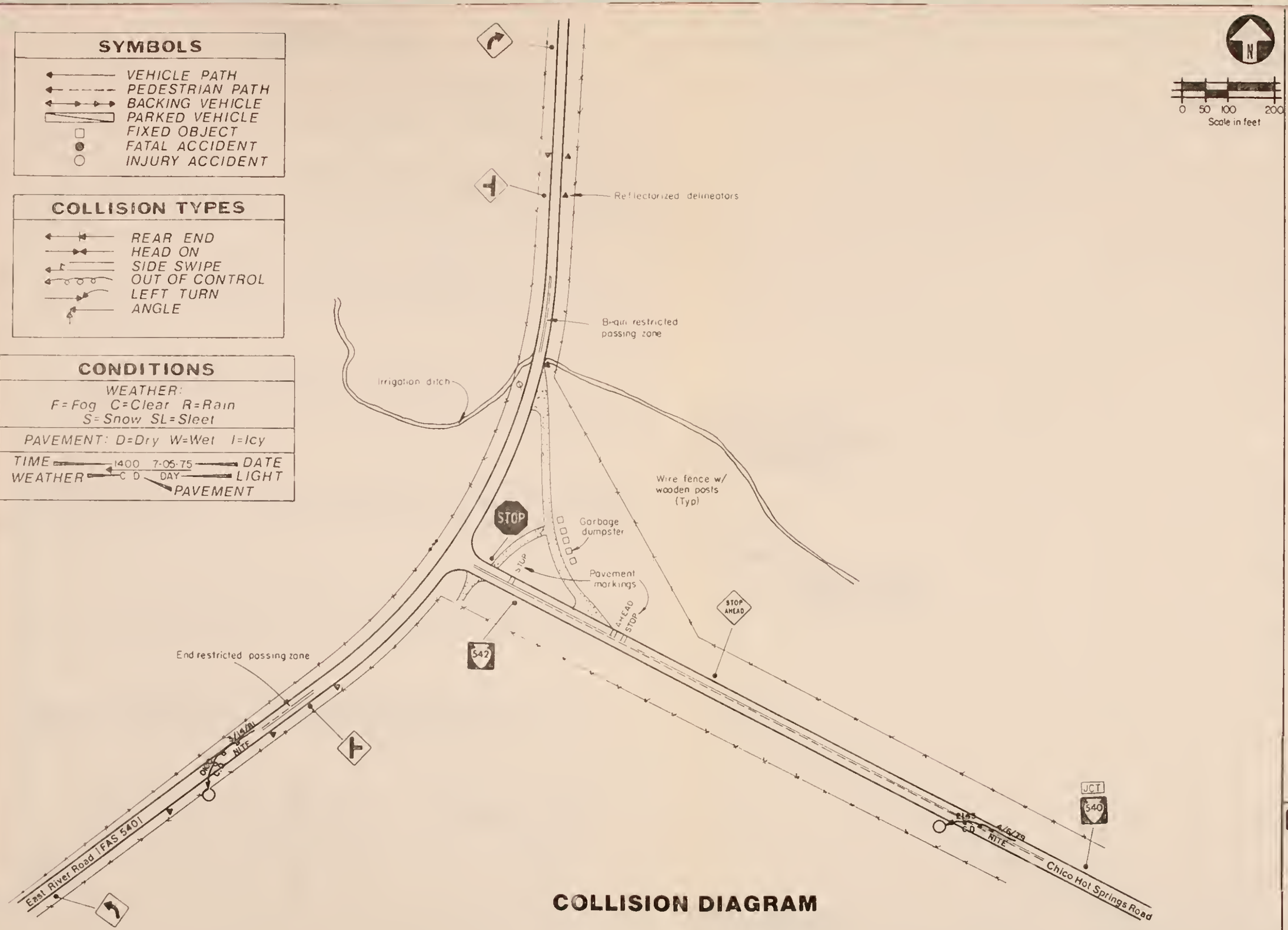
- REAR END
- HEAD ON
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- ANGLE

CONDITIONS

WEATHER:
F=Fog C=Clear R=Rain
S=Snow SL=Sleet

PAVEMENT: D=Dry W=Wet I=Icy

TIME — 1400 — 7-05-75 — DATE
WEATHER — C D — DAY — LIGHT
PAVEMENT



COLLISION DIAGRAM

EAST RIVER ROAD AT CHICO HOT SPRINGS RD.

Site No. 4

Figure No. 4-C

Park Co.

ACCIDENT DATA

Intersection of East River Road & Chico Hot Springs Road

SITE NUMBER 4 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

1978	1979	1980	1981
	1		1

NUMBER OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
					1	1

NUMBER OF ACCIDENTS BY MONTH

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		1	1								

NUMBER OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1																				1			

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

Day-light	Dark	Dawn	Dusk
	2		

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
2				

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
2			

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

Angle	Turn	Rear End	Fixed Obj.	Ped.	Animal	Side-swipe	Non-Col	Head-on	Backing
							2		

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Drinking	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
1								1

NUMBER OF ACCIDENTS BY SEVERITY

	1978	1979	1980	1981
Injury		1		1
Fatality				
Property Dam. Only				

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

2

3. At present, several old black and white dead end barricade sign are attached to the fence on the west side of the intersection. These striped signs should be removed, and a large (48" x 24") double directional arrow (W1-7) should be placed on the west side of the intersection. This arrow should be located so that it is visible on the east approach for a minimum distance of 500 feet.

IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
1	ea	Install Painted Stop Bar	$20	$ 20
1	ea	Remove Existing Stop Sign	$35	35
1	ea	Install Oversized Stop Sign (R1-1, 48" x 48")	$230	230
1	ea	Install Double Directional Arrow (W1-7)	$163	163
Total Cost:				$448

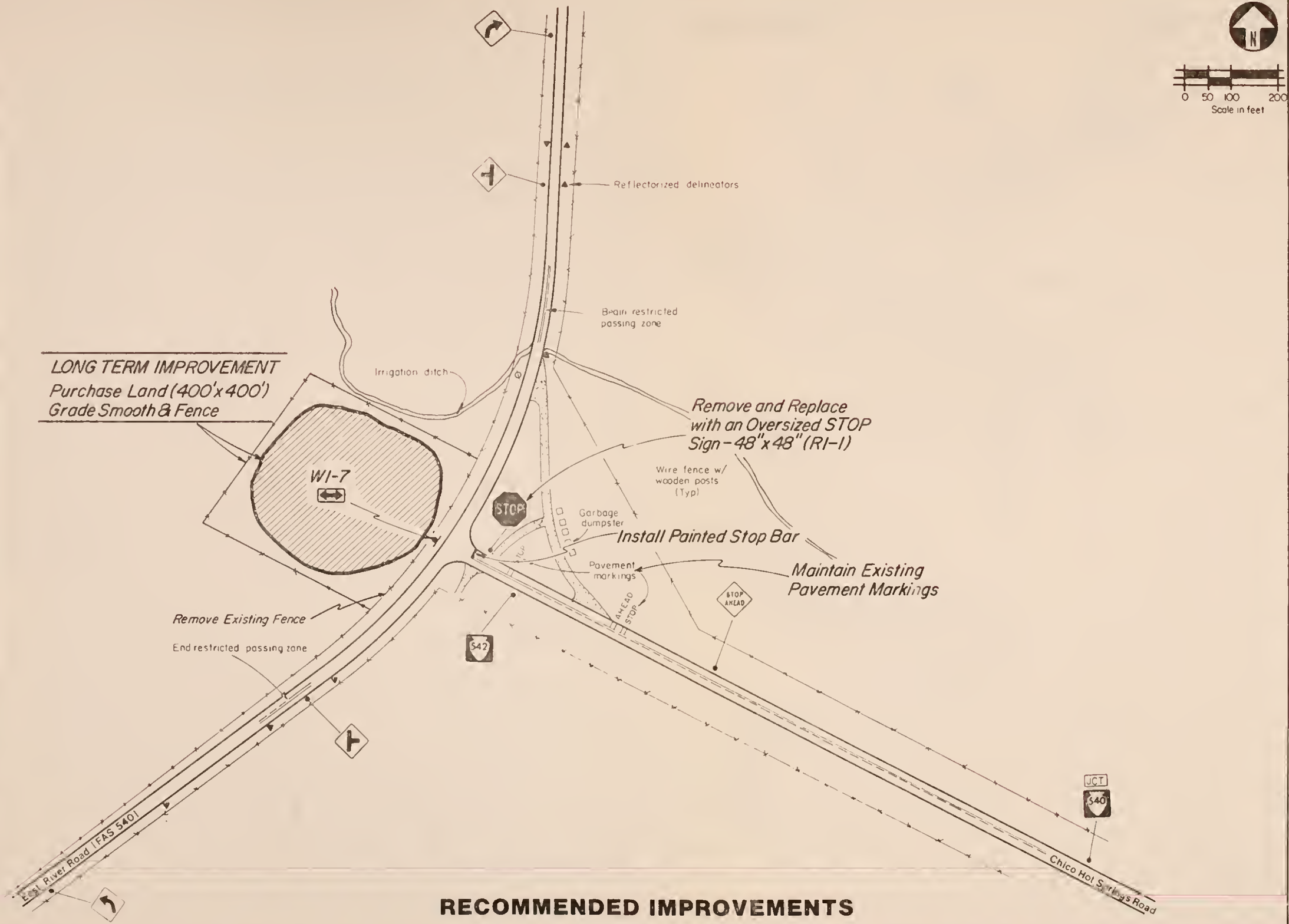
Benefit/Cost Ratio: 3.21

Long-Term Improvements

According to the County Road Foreman, most unreported accidents at this site occur as a result of motorists driving through the intersection, colliding with the fence on the west side of the road, and ending up in the field west of the intersection. It is recommended that the County consider the possibility of purchasing the portion of this field. If a 400' by 400' tract of land were obtained, the fence could be restructured around the parcel and the tract graded smooth, thereby providing a safe overrun area for vehicles that leave the road at this location. If the land cannot be purchased, the County should attempt to gain the landowner's permission to grade the field adjacent to the intersection and remove any boulders that might compound the severity of an accident.

LONG-TERM IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
-	Lump Sum	Purchase Land, Grade, and Fence	-	$2,500



RECOMMENDED IMPROVEMENTS

EAST RIVER ROAD AT CHICO HOT SPRINGS RD.

Site No. 4

Figure No. 4-D

Park Co.

DETERMINATION OF HAZARD INDEX

Site Number *4* Date *December, 1982*

Site Description *Intersection of East River Road & Chico Hot Springs Road*

Indicator	Data Value	Indicator Value	Weight	Partial H.I.'s
Number of Accidents	*.5* acc/yr	*17*	x 0.164 =	*2.79*
Accident Rate	*4.7* acc/MVE	*65*	x 0.225 =	*14.63*
Accident Severity	*11,450* dollars	*65*	x 0.191 =	*12.42*
Volume/Capacity Ratio	*.07*	*22*	x 0.082 =	*1.80*
Sight Distance Ratio	*1.12* (wt. avg.)	*26*	x 0.074 =	*1.92*
Driver Expectancy	*3.0* (wt. avg.)	*50*	x 0.149 =	*7.45*
Information System Deficiencies	*1.5* (wt. avg.)	*25*	x 0.115 =	*2.88*

Hazard Index: *43.89*

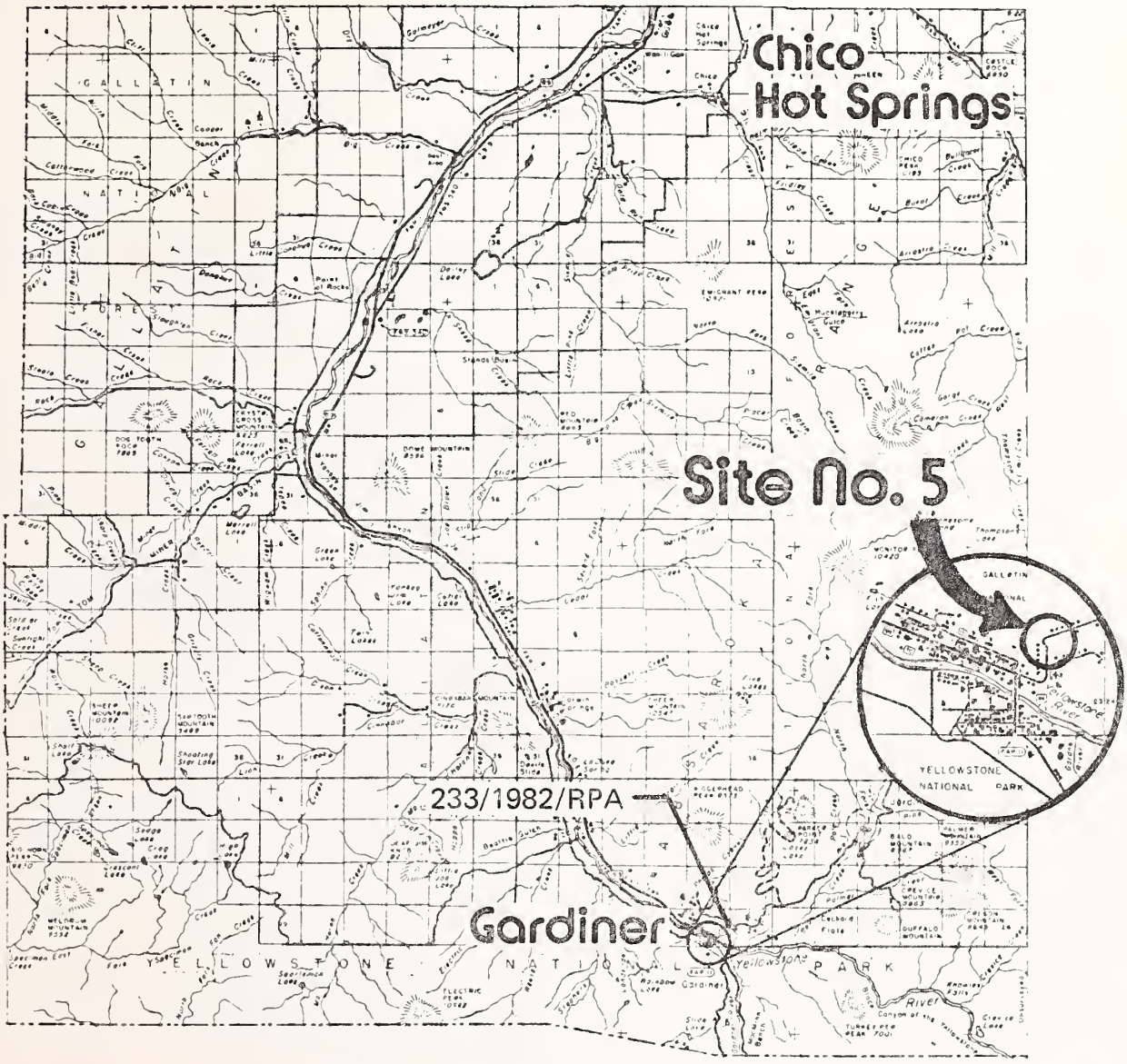
Cost of Recommended Improvements: *$448*

Cost Factor: *98*

Priority Index = Hazard Index x .75 + Cost Factor x .25

43.89 x .75 + *98* x .25 = *57.42*

Site no. 5



Average Daily Traffic/Year of Count/Source of Count

121/1982/RPA

SITE LOCATION
TRAFFIC COUNTS
LOWER JARDINE ROAD - GARDINER

Figure No.
5-A
Park Co.

SITE #5

Lower Jardine Road at Gardiner

A. Location

Site #5 is located .3 miles northeast of US 89 (FAP 11) in Gardiner and consists of a hairpin curve on the Jardine Road. The site is located in a new residential area on the north side of Gardiner. In addition to providing access to scattered residences in the area, the route is heavily used during the fall to provide access to hunting areas in the Jardine Area. The route is also used to transport travertine from a quarry located a mile north of the site on the Jardine Road. The location of this site and the traffic count for the roadway is presented in Figure 5A.

B. Existing Conditions

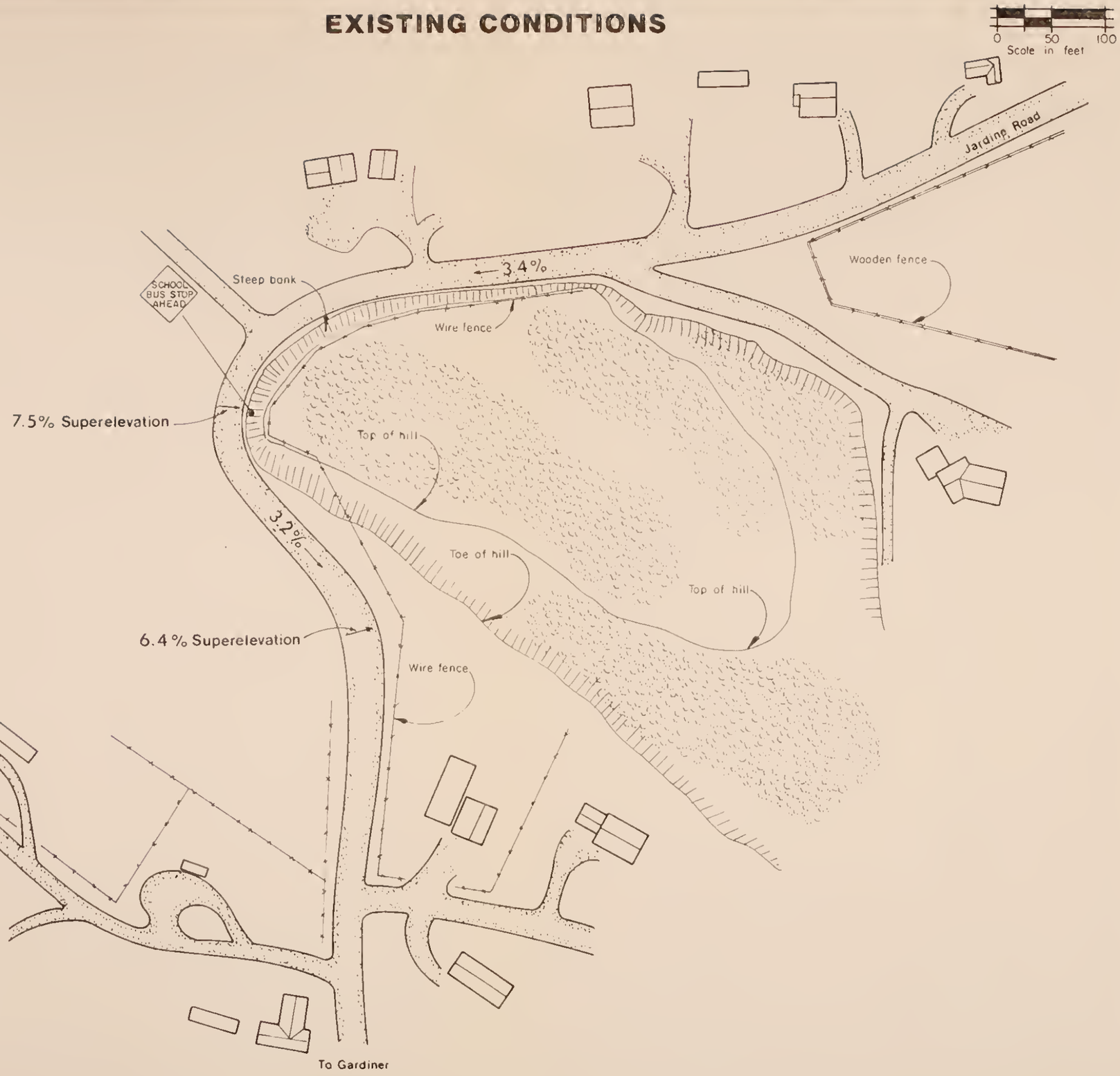
The lower Jardine Road at Site #5 is a gravel-surfaced roadway varying in width from 24 to 30 feet. Road grades at the site are relatively constant at between 3 and 3.5 percent sloping toward Gardiner. Superelevations in the curves at the site are adequate; the curve in the south approach has a superelevation of 6.4 percent and the hairpin curve itself has a 7.5 percent superelevation. The abrupt change in road alignment caused by the terrain limits sight distance to less than 100 feet in several locations within the curve. The steep face of the hill in the corner consists of rock and some loosely consolidated materials. It appears that due to the limited right-of-way and the type of soil material in the hill, very little additional material may be removed from the hill face on the inside of the curve. The only signing within the site is a school bus stop ahead sign (S3-1) located on the south approach to the curve. The posted speed limit on Jardine Road near the intersection with US 89 is 25 mph. Existing site conditions are depicted in the site sketch (Figure 5B) and in site photographs contained in Plate 5.

Based on machine counts of 24-hour traffic volumes conducted by Robert Peccia & Associates during October, 1982, it was determined that the average daily traffic for this site is 233 vehicles.

C. Accident History

A total of four accidents were reported at this site on lower Jardine Road during the past four years. All of the accidents resulted in injuries to a total of four persons, and included three single-vehicle collisions with fixed objects and one two-vehicle collision. In two of the single-vehicle accidents, the vehicles left the roadway and rolled over; the other single-vehicle accident resulted when the vehicle struck a car parked along the roadway. The two-vehicle accident occurred in the blind hairpin corner of the site and was a head-on collision. Three of the four accidents occurred during the day, and the majority occurred during clear weather and dry road condi-

EXISTING CONDITIONS



LOWER JARDINE ROAD
AT GARDINER

Site No. 5

Figure No.
5·B
Park Co.

Existing Site Conditions

View of west approach to the hairpin curve at Site 5. Note "School Bus Stop Ahead" sign in the curve.

View of east approach to the curve. Note lack of curve warning signing or curve delineation.

View of east approach to the site. Note the location of fencing and the steep bank.

Sight distance in the curve is limited to about 100 feet due to the change in roadway alignment and terrain.

Plate 5

COLLISION DIAGRAM

SYMBOLS

- VEHICLE PATH
- PEDESTRIAN PATH
- BACKING VEHICLE
- PARKED VEHICLE
- FIXED OBJECT
- FATAL ACCIDENT
- INJURY ACCIDENT

COLLISION TYPES

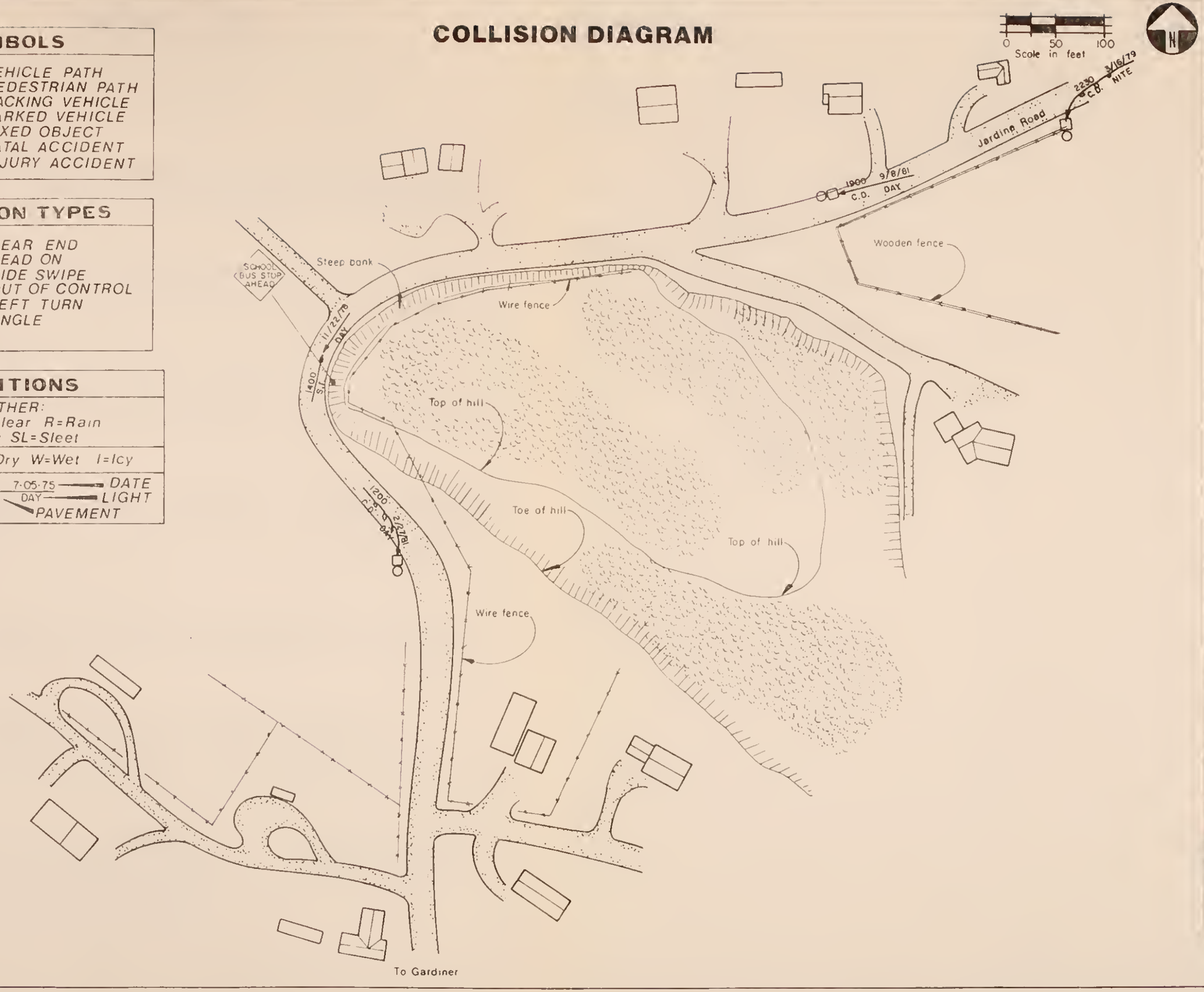
- REAR END
- HEAD ON
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- ANGLE

CONDITIONS

WEATHER:
F=Fog C=Clear R=Rain
S=Snow SL=Sleet

PAVEMENT: D=Dry W=Wet I=Icy

TIME — 1400 7-05-75 — DATE
WEATHER — C D DAY — LIGHT
PAVEMENT



LOWER JARDINE ROAD AT GARDINER

Site No. 5

Figure No. 5-C

Park Co.

ACCIDENT DATA

Lower Jardine Road (Gardiner)

SITE NUMBER 5 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

1978	1979	1980	1981
1	1		2

NUMBER OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
		1	1		2	

NUMBER OF ACCIDENTS BY MONTH

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1	1						1		1	

NUMBER OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
											1		1					1			1		

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

Day-light	Dark	Dawn	Dusk
3	1		

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
3			1	

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
3		1	

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

Angle	Turn	Rear End	Fixed Obj.	Ped.	Animal	Side-swipe	Non-Col	Head-on	Backing
			3					1	

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Drinking	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
1	2	1						

NUMBER OF ACCIDENTS BY SEVERITY

	1978	1979	1980	1981
Injury	1	1		2
Fatality				
Property Dam. Only				

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

2

tions. Only one accident oeeurred during adverse weather and road eonditions. The majority of the accidents at this site were the result of reckless driving or drinking. The composite collision diagram for the site is depicted in Figure 5C.

D. Reeommendations

The major problem at this site is the sharp curve in Jardine Road. The optimum solution would be to straighten the road through the site, but unfortunately this is not economically feasible to do. The short-term improvements listed below concentrate on properly signing and delineating this curve.

1. The sharp curve at this site is totally unexpected and is not signed at the present time. It is recommended that curve warning signs (W1-5a) be installed on both approaches. A ball bank indicator was used to determine that 15 mph is the maximum safe speed for this curve, and therefore 15 mph advisory speed plates (W13-1) should be presented with the curve warning signs. The sign on the approach from Gardiner should be located 150 feet from the eurve. Setback distances are usually greater than this, but due to the road configuration and the slow vehicle speeds caused by the uphill grade, 150 feet is aeceptable. The warning sign on the approach from Jardine should be loeated 250 feet from the beginning of the curve.

2. To further identify this curve, a series of 12 chevron warning signs (W1-8) should be installed in the curve to delineate the road alignment for both approaches and guide motorists through the curve. These chevrons should be located so that at least three signs are visible to motorists at all times. The recommended plaeement and spacing of these warning signs are shown in Figure 5D.

3. The existing school bus stop ahead sign (S1-3) is located in the curve itself. Because motorists are concentrating on negotiating the eurve when they see this sign, it is not as effective as it could be. It is recommended that this sign be relocated approximately 100 feet to the south. At this new location, drivers will see the sign before entering the curve and therefore it should be more effective.

4. The wide curve at the lower end of the site should be delineated. It is recommended that reflectorized delineators (Design C, 4" x 4", silver) be installed around the outside of the curve. A spacing of 45 feet should be used in the curve. The recommended placement of these reflectors is shown in Figure 5D.

5. The road surface width in the sharp curve at this site should be increased to allow more room for vehicles to maneuver. Fill material should be placed on the outside of the curve to widen it to at least 30 feet. This additional width is considered necessary because of the tight radius of the curve and the frequent use of this road by large mining vehieles.

IMPROVEMENT COST ESTIMATE

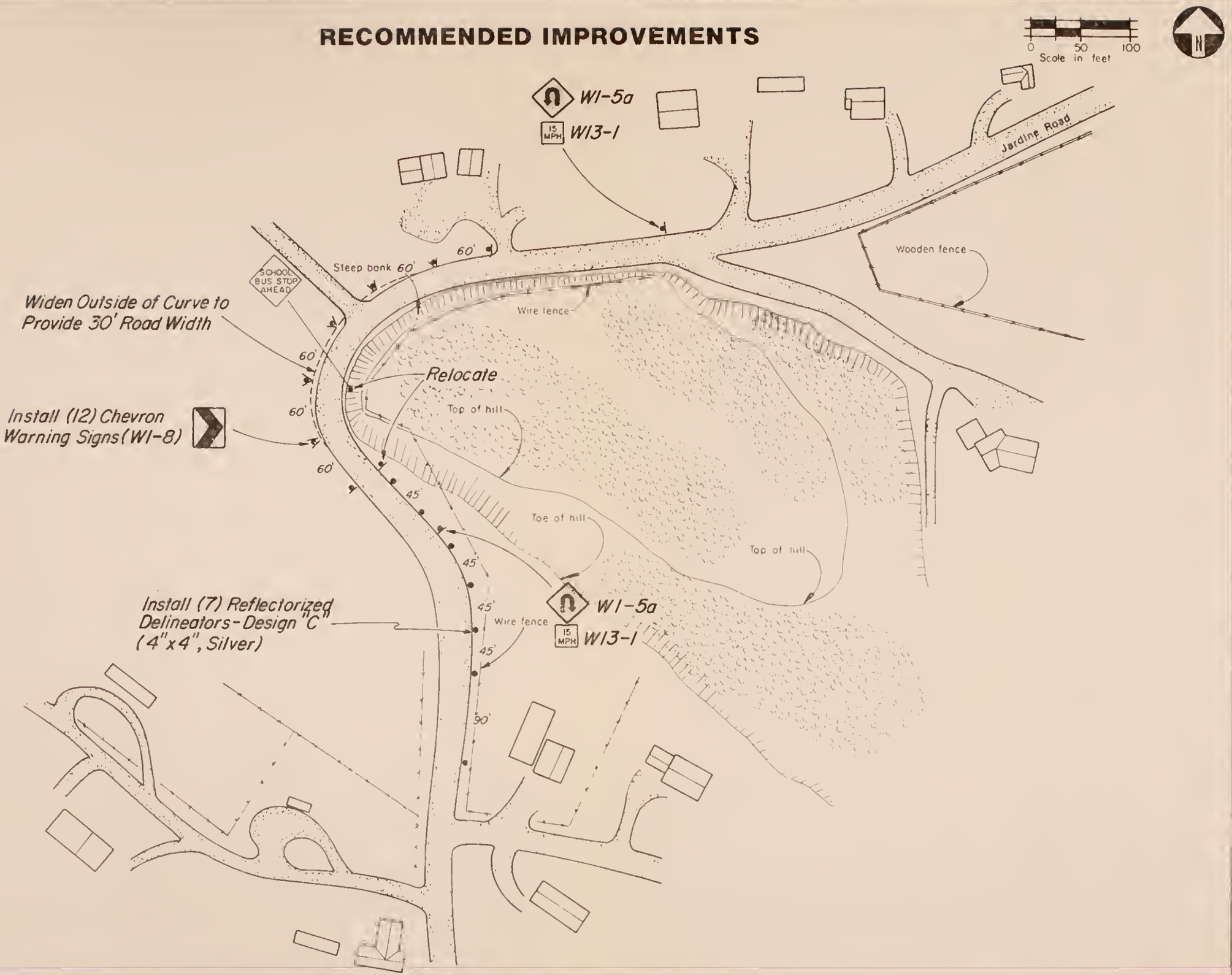
Quantity	Unit	Item Description	Unit Price	Total Price
2	ea	Install Curve Warning Signs (W1-5a) with 15 mph Advisory Speed Plates	$180	$ 360
12	ea	Install Chevron Warning Signs (W1-8)	$130	1,560
1	ea	Relocate Existing School Bus Stop Ahead Sign (S1-3)	$105	105
7	ea	Install Reflectorized Delineators (Design C, 4" x 4", silver)	$18	126
-	Lump Sum	Widen Road Surface to 30 Feet in Curve	-	2,000
Total Cost:				$4,151

Benefit/Cost Ratio: 3.23

Long-Term Improvements

Due to the local geography, realignment of this section of road is not considered financially feasible. The short-term improvements outlined above address the problems at this site with the present alignment; therefore, no long-term improvements are recommended.

RECOMMENDED IMPROVEMENTS



Site No. 5

LOWER JARDINE ROAD AT GARDINER

Figure No.
5-D
Park Co.

DETERMINATION OF HAZARD INDEX

Site Number *5* Date *December, 1982*

Site Description *Lower Jardine Road (Gardiner)*

Indicator	Data Value	Indicator Value	Weight	Partial H.I.'s
Number of Accidents	*1.0* acc/yr	*26*	x 0.164 =	*4.26*
Accident Rate	*11.8* acc/MVE	*100*	x 0.225 =	*22.5*
Accident Severity	*13,125* dollars	*72*	x 0.191 =	*13.75*
Volume/Capacity Ratio	*.42*	*60*	x 0.082 =	*4.92*
Sight Distance Ratio	*.5* (wt. avg.)	*100*	x 0.074 =	*7.40*
Driver Expectancy	*4.8* (wt. avg.)	*80*	x 0.149 =	*11.92*
Information System Deficiencies	*5.0* (wt. avg.)	*83*	x 0.115 =	*9.55*

Hazard Index: *74.30*

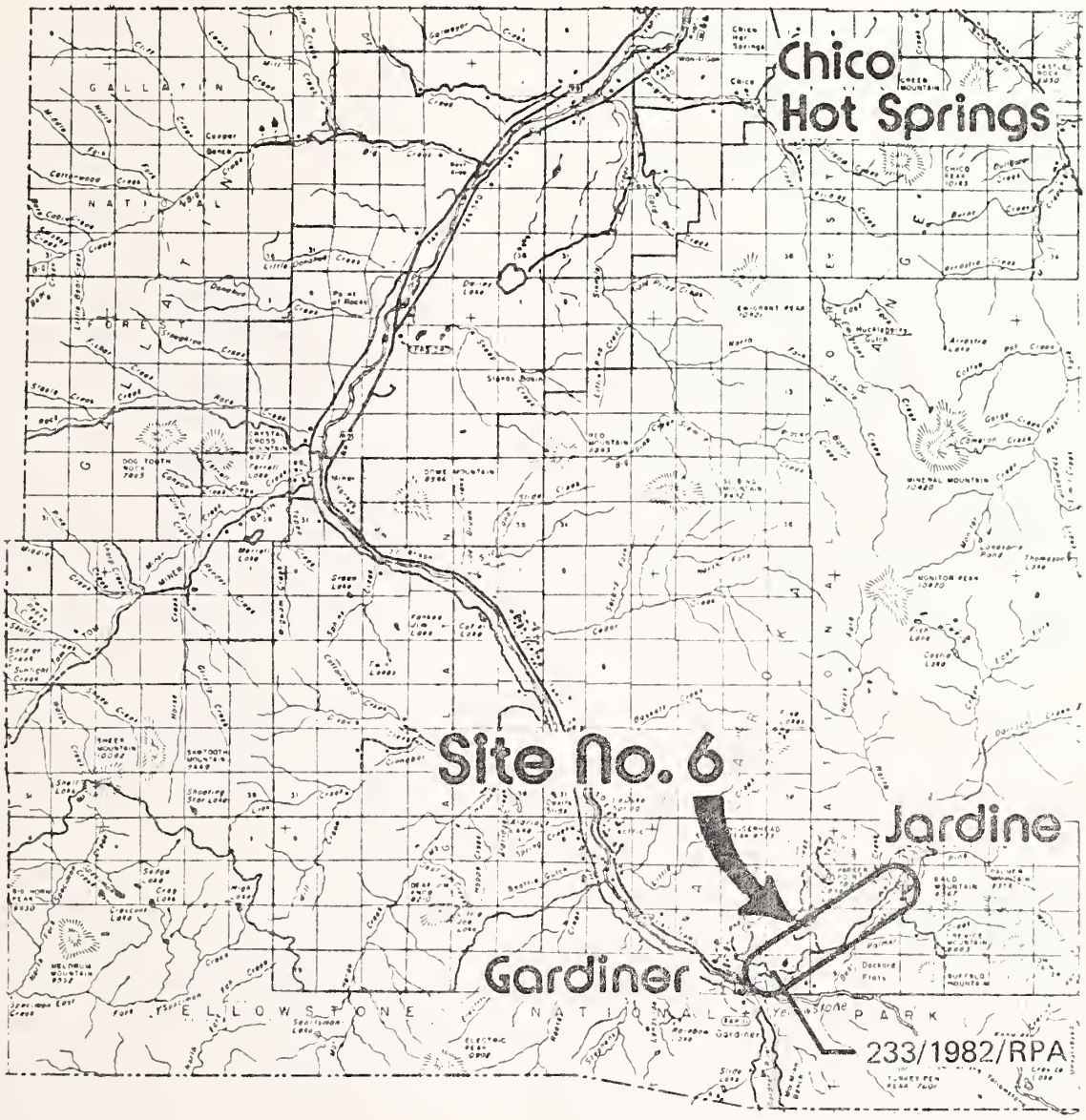
Cost of Recommended Improvements: *$4,151*

Cost Factor: *80*

Priority Index = Hazard Index x .75 + Cost Factor x .25

74.30 x .75 + *80* x .25 = *75.73*

Site no. 6



Average Daily Traffic/Year of Count/Source of Count

121/1982/RPA

SITE LOCATION
TRAFFIC COUNTS
UPPER JARDINE ROAD

Figure No.
6-A
Park Co.

SITE #6

Upper Jardine Road

A. Location

Site #6 consists of a 4.3-mile section of the Jardine Road extending from the initial switchbacks near Gardiner to the southwestern edge of Jardine. The site is located in steep, open terrain for the first 3.5 miles and then in the narrow, steep-walled gulch which drains Bear Creek. Local traffic consists of residential traffic from Jardine and traffic to and from the travertine mine near Gardiner. The heaviest traffic at the site occurs during the fall when outfitters and hunters utilize the roadway to gain access to remote hunting areas. Additional recreation traffic results from visitors to the old mining facilities in Jardine and the Eagle Creek Recreation Area. The location of this site and traffic data for the Jardine Road are presented in Figure 6A.

B. Existing Conditions

The Jardine Road at this site is a gravel-surfaced roadway varying in width from 24 to 30 feet, and is in fair condition over most of the length of this site. The roadway is constructed through generally rolling terrain with grades ranging from 2 to a maximum of 8 percent. Due to the curves and grades within the site, sight distance is restricted to less than 100 feet in numerous locations. The most hazardous condition associated with the Jardine Road is the extremely steep slope adjacent to the south side of the road in many places. Much of this steep roadside embankment has a minimum slope of 1:1. Signing throughout the site is minimal, with most located near the community of Jardine. A school bus stop sign and a 25 mph speed limit sign are posted at this location. Existing site conditions are depicted in the photographs contained in Plates 6A and 6B.

Twenty-four hour machine counts of traffic volumes were collected by Robert Peccia & Associates during October, 1982. Based on this data, the average daily traffic on the Jardine Road was estimated to be 233 vehicles per day.

C. Accident History

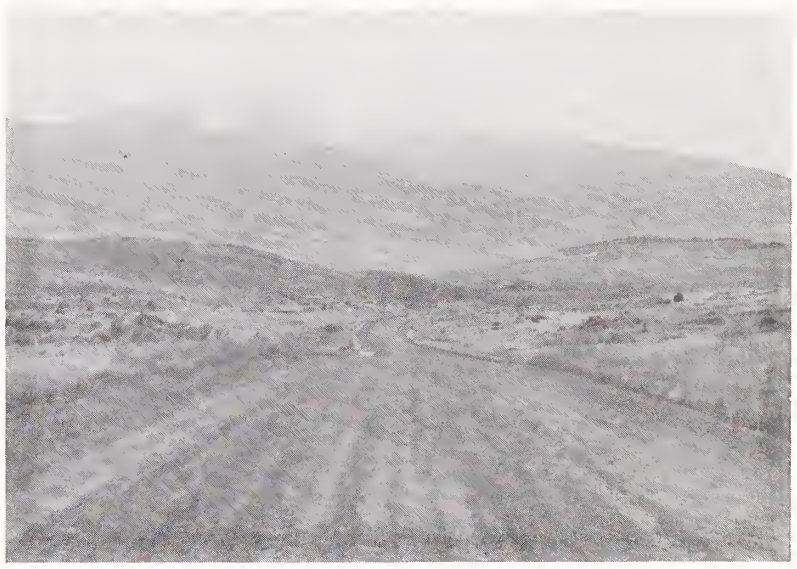
A total of five accidents were recorded at this site during the four-year study period. These accidents resulted in one fatality and one injury. All five accidents were single-vehicle accidents in which each vehicle left the roadway surface and collided with roadside objects. Four of the five vehicles rolled down the steep embankment adjacent to the roadway. Three of the five accidents occurred during daylight hours, and nearly all occurred during clear weather and dry road conditions. The major contributing factors to accidents along this section of the Jardine Road were excessive speed for road

Existing Site Conditions

View of steep portion of the Jardine Road northeast of Gardiner. Grades exceed 8 percent at this location.

View of the roadway and terrain west of the Eagle Creek Road intersection.

View of Jardine Road from the second of the two major switchbacks in this portion of Site 6.



View of rolling terrain typical of the high plateau east of Gardiner.

Plate 6A

Existing Site Conditions

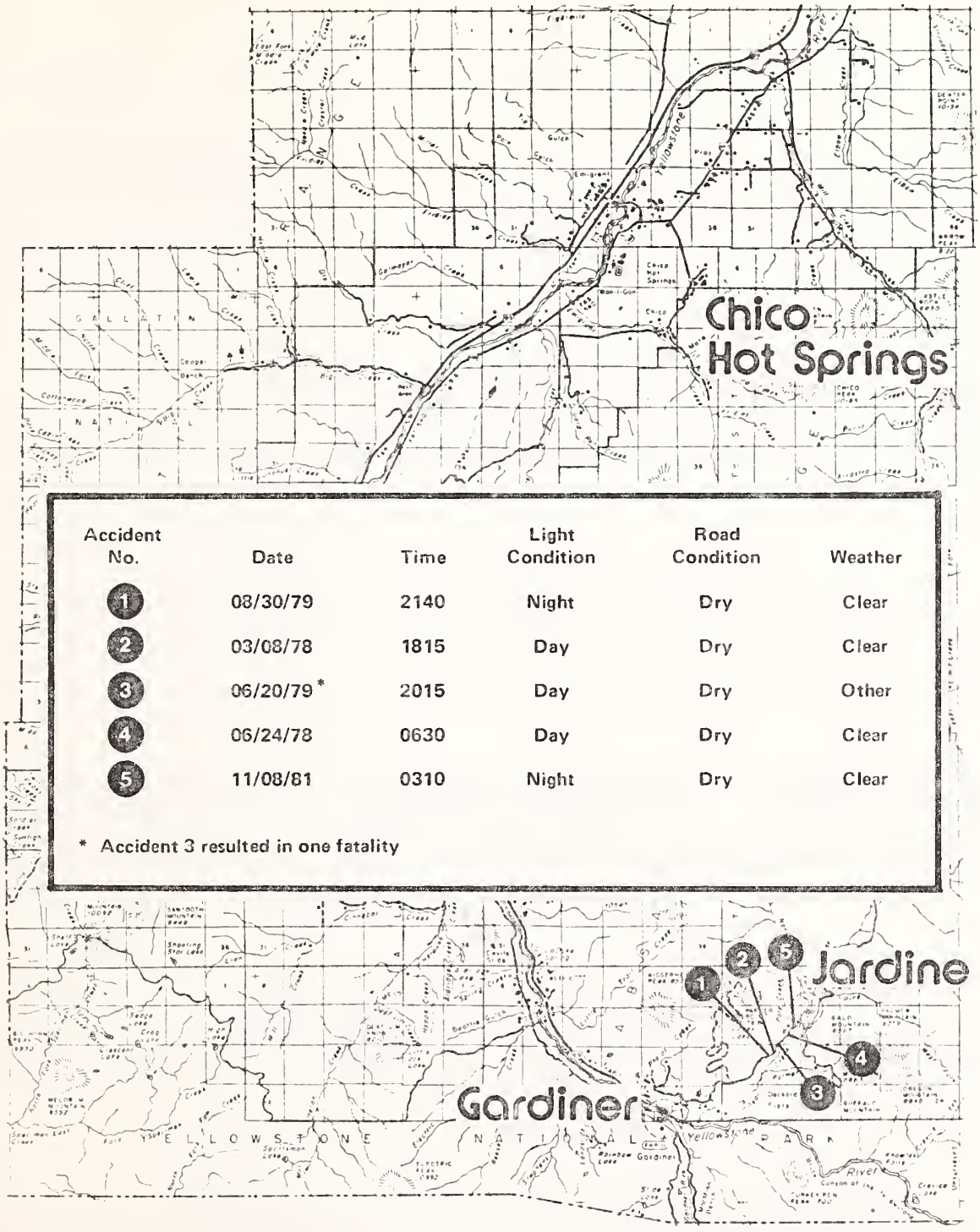
View of roadway and terrain typical of the two miles of the Jardine Road west of Jardine.

Typical area of restricted sight distance caused by a sharp change in grade and roadway alignment.

Note steep areas adjacent to the south side of the road. These areas exceed 1:1 slopes in numerous areas along the roadway.

Speed limit signing near the community of Jardine.

Plate 6B



Accident No.	Date	Time	Light Condition	Road Condition	Weather
1	08/30/79	2140	Night	Dry	Clear
2	03/08/78	1815	Day	Dry	Clear
3	06/20/79 *	2015	Day	Dry	Other
4	06/24/78	0630	Day	Dry	Clear
5	11/08/81	0310	Night	Dry	Clear

* Accident 3 resulted in one fatality

ACCIDENT LOCATIONS

UPPER JARDINE ROAD

Figure No. 6-B

Park Co.

ACCIDENT DATA

Upper Jardine Road

SITE NUMBER 6 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

1978	1979	1980	1981
2	2		1

NUMBER OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
1			2	1		1

NUMBER OF ACCIDENTS BY MONTH

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		1			2		1			1	

NUMBER OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
		1			1												1		1	1			

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

Day-light	Dark	Dawn	Dusk
3	2		

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
5				

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS*

Clear	Rain	Snow	Fog
4			

* plus 1 under cloudy conditions

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

Angle	Turn	Rear End	Fixed Obj.	Ped.	Animal	Side-swipe	Non-Col	Head-on	Backing
			5						

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Drinking	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
	1		3					1

NUMBER OF ACCIDENTS BY SEVERITY

	1978	1979	1980	1981
Injury				1
Fatality		1		
Property Dam. Only	2	1		

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

2

conditions and drinking, which was involved in two of the five reported accidents at the site. Accident locations and circumstances are presented in Figure 6B.

D. Recommendations

The road from Gardiner to Jardine has a wide variety of problems. The winding, rolling alignment of the road often limits sight distance and makes driving during snow-packed or icy conditions very dangerous. In many cases, spot road reconstruction can improve the available sight distance. At present, there is little guidance given to motorists through signing. The short-term improvements listed below address the lack of adequate signing and the long-term improvements concentrate on spot road reconstruction. Due to the length of this site, the location of each improvement is referenced in miles from the intersection of the Jardine Road with US 89 in Gardiner.

1. (3.3 through 4.2 miles from US 89) This section of the Jardine Road contains several sharp switchbacks where grades vary from 5 to 8 percent. Negotiating this section of road requires that motorists be very alert and drive slowly to maintain control in the curves. This section of road should be properly signed and delineated. A ball bank indicator was used to determine that 10 mph is the maximum safe speed for these switchback curves. It is recommended that curve warning signs (W1-5a) depicting a switchback curve be installed on both approaches to the two sharp curves on the hill. Ten mph advisory speed plates (W13-1) should accompany these curve warning signs. The signs should be located 250 feet from the beginning of each curve.

This steep winding hill should also be defined for westbound motorists before beginning the descent of the hill by installing a hill sign (W7-1) 500 feet east of the hill. In addition, due to the large volume of campers and towing units that use this road, a supplementary plaque depicting "Trucks Use Low Gear" (W7-2) should accompany the hill sign.

To delineate the alignment of the road on the hill, reflectorized delineators (Design C, 4" x 4", silver) should be placed on the downhill side of the road spaced 200 feet apart on the tangent sections and progressively closer together on the immediate curve approach. In the curve, delineators should be spaced approximately 45 feet apart. These reflectors should be placed on the outside shoulder in the curves.

2. Reflectorized delineators (Design C, 4" x 4", silver) should be used to guide motorists through the various curves on the Jardine Road. In all cases the delineators should be spaced 45 feet apart in the curves and 90 feet apart on the curve approaches. A minimum of two reflectors should be installed on each curve approach, and they should be placed on the outside shoulders of each curve. Six curves along this road should be delineated in this manner; they are located at 4.85, 5.05, 5.45, 6.25, 6.5, and 6.85 miles from the intersection of US 89, respectively.

3. In an effort to control the vehicle speeds, 25 mph speed limit signs (R2-1) should be posted along this section of the Jardine Road every mile. In addition, enforcement of the speed limit should be increased. Excessive speed was a contributing factor in most of the reported accidents at this site.

4. (6.9 through 7.6 miles from US 89) The steep dropoff into Bear Creek on the south side of the road presents a major hazard to motorists. It is recommended that reflectorized delineators (Design C, 4" x 4", silver) be installed along this section of road to identify the south edge of the travelway. The use of these reflectors will serve to constantly remind motorists of the roadway alignment, and will also tend to instill caution in the motorists. These reflectors should be installed using a 200-foot delineator spacing.

IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
4	ea	Install Curve Warning Signs (W1-5a) with 10 mph Advisory Speed Plates (W13-1)	$180	$ 720
1	ea	Install Hill Warning Sign (W7-1) with "Trucks Use Low Gear" Advisory Plate (W7-2)	$180	180
8	ea	Install 25 mph Speed Limit Signs (R1-2)	$130	1,040
110	ea	Install Reflectorized Delineators (Design C, 4" x 4", silver)	$18	1,980
Total Cost:				$3,920

Benefit/Cost Ratio: 1.48

Long-Term Improvements

The road to Jardine follows the natural contours of the area, winding and rolling with the land. In many cases, due to abrupt changes in the horizontal and/or vertical alignment, the available sight distance is reduced to 100 feet or less. It is therefore recommended to perform spot road reconstruction to improve sight distances as a long-term improvement. In the case

of a change in vertical grade where a hillcrest limits sight distance, the vertical curve should be lengthened, the crest cut down, and the material removed. In some cases, such improvements may create a snow catch, so roadside embankments may also have to be sloped back. Two locations in particular where the crest in the road creates such a problem are at 4.55 and 6.1 miles from the intersection with US 89.

There are a variety of curves that require some modification to improve sight distance. In these cases, embankments on the inside of the curves are obstructing the motorists views. This material should be excavated and the bank sloped back to increase sight distance to a minimum of 200 feet. There are five curves in particular where this treatment should be used; at 4.55, 4.85, 5.05, 5.45, and 6.85 miles from the intersection with US 89.

In addition, there are two locations along the Jardine Road where a combination of a curve and a crest in the road present difficulties to motorists. They are located at 6.25 and 6.5 miles from US 89, respectively. In these cases, both the inside embankment and the crest in the road should be altered as described above to achieve the desired sight distance.

The steep grade and sharp switchback curves on the western portion of the Jardine Road constitute a major hazard. Although signing and delineation of this section of road was addressed in the short-term improvements, this stretch of road meets warrants for the installation of guard rail. It is therefore recommended that 300-foot-long sections of guard rail be installed in each of the switchback curves on the outside of each curve.

LONG-TERM IMPROVEMENT COST ESTIMATE

Quantity	Unit	Item Description	Unit Price	Total Price
-	Lump Sum	Earthwork (Dozer, Patrol, Loader and Hauling)	-	$18,000
900	lf	Guard Rail	$9	8,100
Total Cost:				$26,100

DETERMINATION OF HAZARD INDEX

Site Number *6* Date *December, 1982*

Site Description *Upper Jardine Road*

Indicator	Data Value	Indicator Value	Weight	Partial H.I.'s
Number of Accidents	*1.25* acc/yr	*30*	x 0.164 =	*4.92*
Accident Rate	*14.7* acc/MVE	*100*	x 0.225 =	*22.5*
Accident Severity	*12,020* dollars	*67*	x 0.191 =	*12.8*
Volume/Capacity Ratio	*.42*	*60*	x 0.082 =	*4.92*
Sight Distance Ratio	*.75* (wt. avg.)	*58*	x 0.074 =	*4.29*
Driver Expectancy	*5.0* (wt. avg.)	*83*	x 0.149 =	*12.37*
Information System Deficiencies	*4.5* (wt. avg.)	*75*	x 0.115 =	*8.63*

Hazard Index: *70.43*

Cost of Recommended Improvements: *$3,920*

Cost Factor: *81*

Priority Index = Hazard Index x .75 + Cost Factor x .25

70.43 x .75 + *81* x .25 = *73.07*

CHAPTER V
BIBLIOGRAPHY

BIBLIOGRAPHY

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Identification, Analysis and Correction of High Accident Locations, Federal Highway Administration and Missouri State Highway Commission, November, 1975.

CHAPTER VI
APPENDIX

DETERMINATION OF HAZARD INDEX

Site Number _____ Date _____

Site Description _____

Indicator	Data Value	Indicator Value	Weight	Partial H.I.'s
Number of Accidents	_____ acc/yr	_____	x 0.164 =	_____
Accident Rate	_____ acc/MVE	_____	x 0.225 =	_____
Accident Severity	_____ dollars	_____	x 0.191 =	_____
Volume/Capacity Ratio	_____	_____	x 0.082 =	_____
Sight Distance Ratio	_____ (wt. avg.)	_____	x 0.074 =	_____
Driver Expectancy	_____ (wt. avg.)	_____	x 0.149 =	_____
Information System Deficiencies	_____ (wt. avg.)	_____	x 0.115 =	_____

Hazard Index: _____

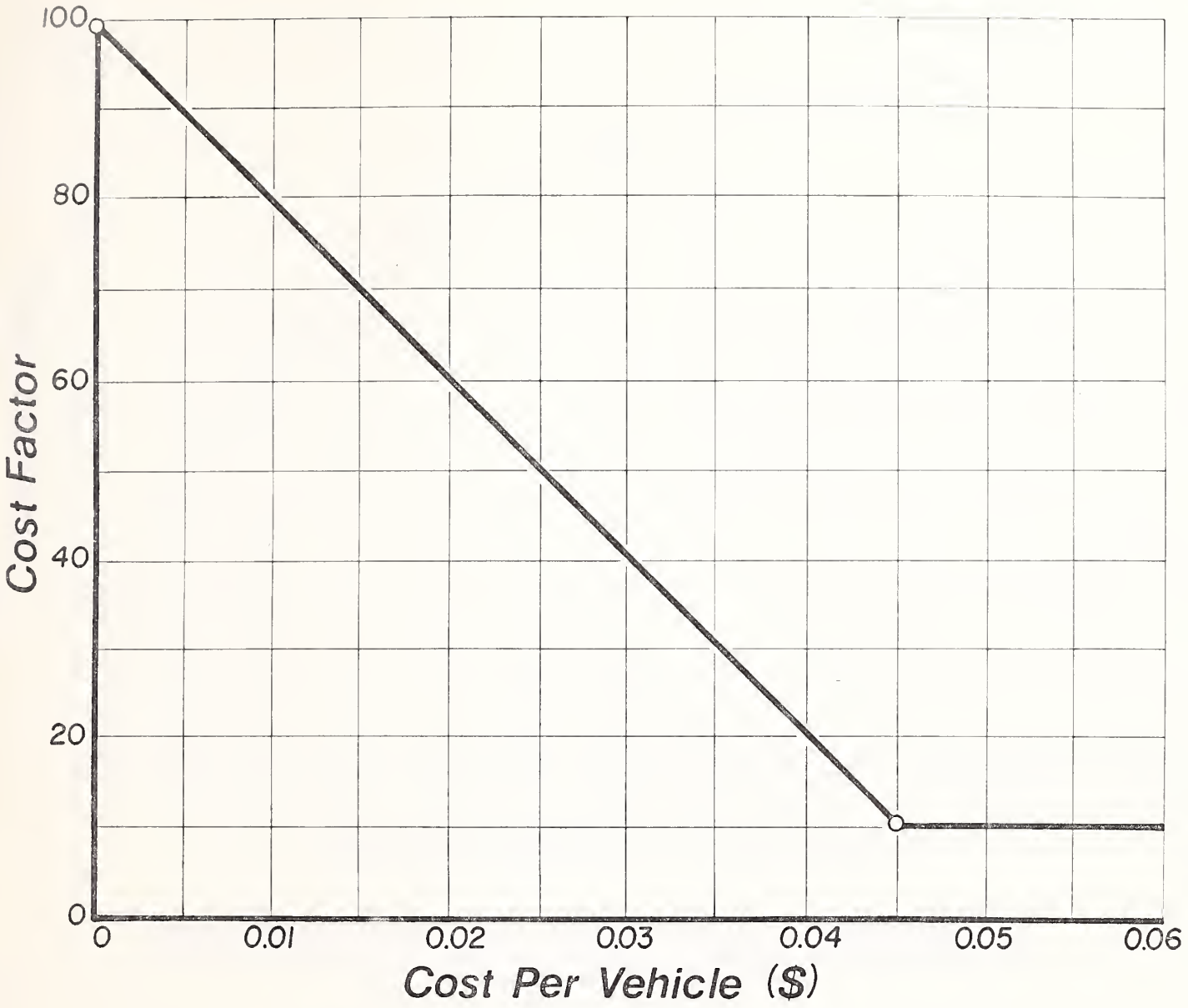
Cost of Recommended Improvements: _____

Cost Factor: _____

Priority Index = Hazard Index x .75 + Cost Factor x .25

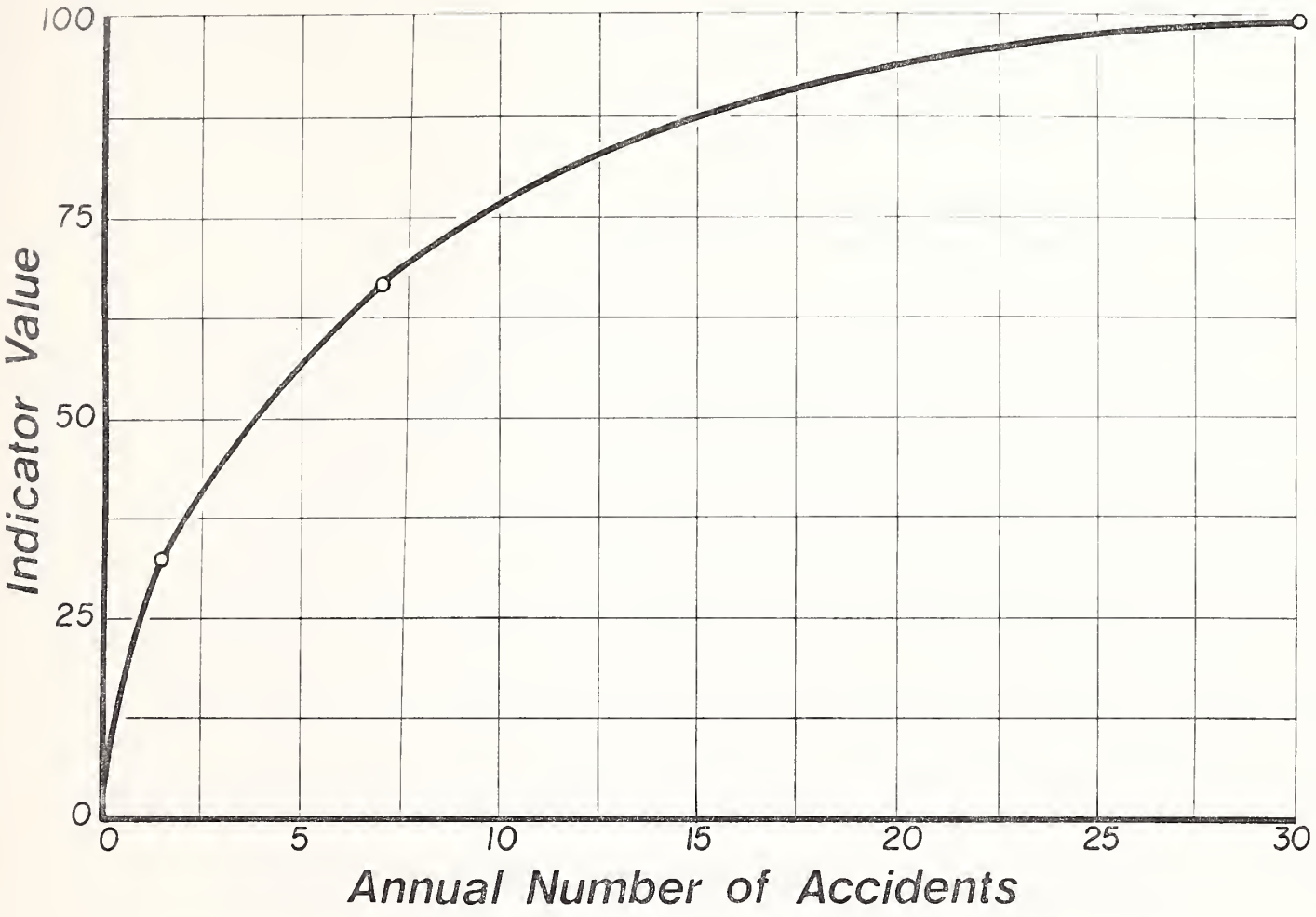
_____ x .75 + _____ x .25 = _____

FIGURE A1



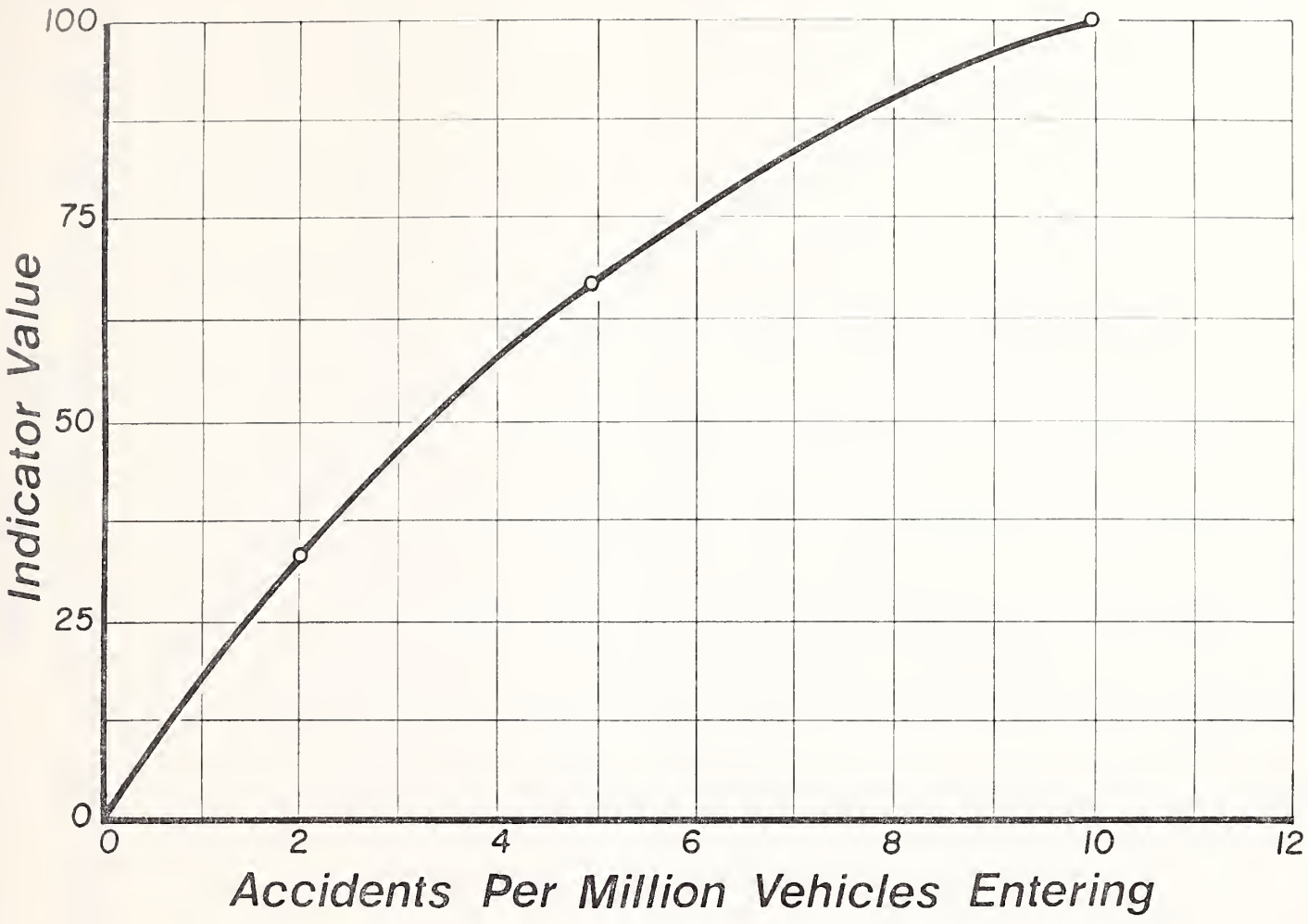
FORM FOR DETERMINATION
OF COST FACTOR

FIGURE A2



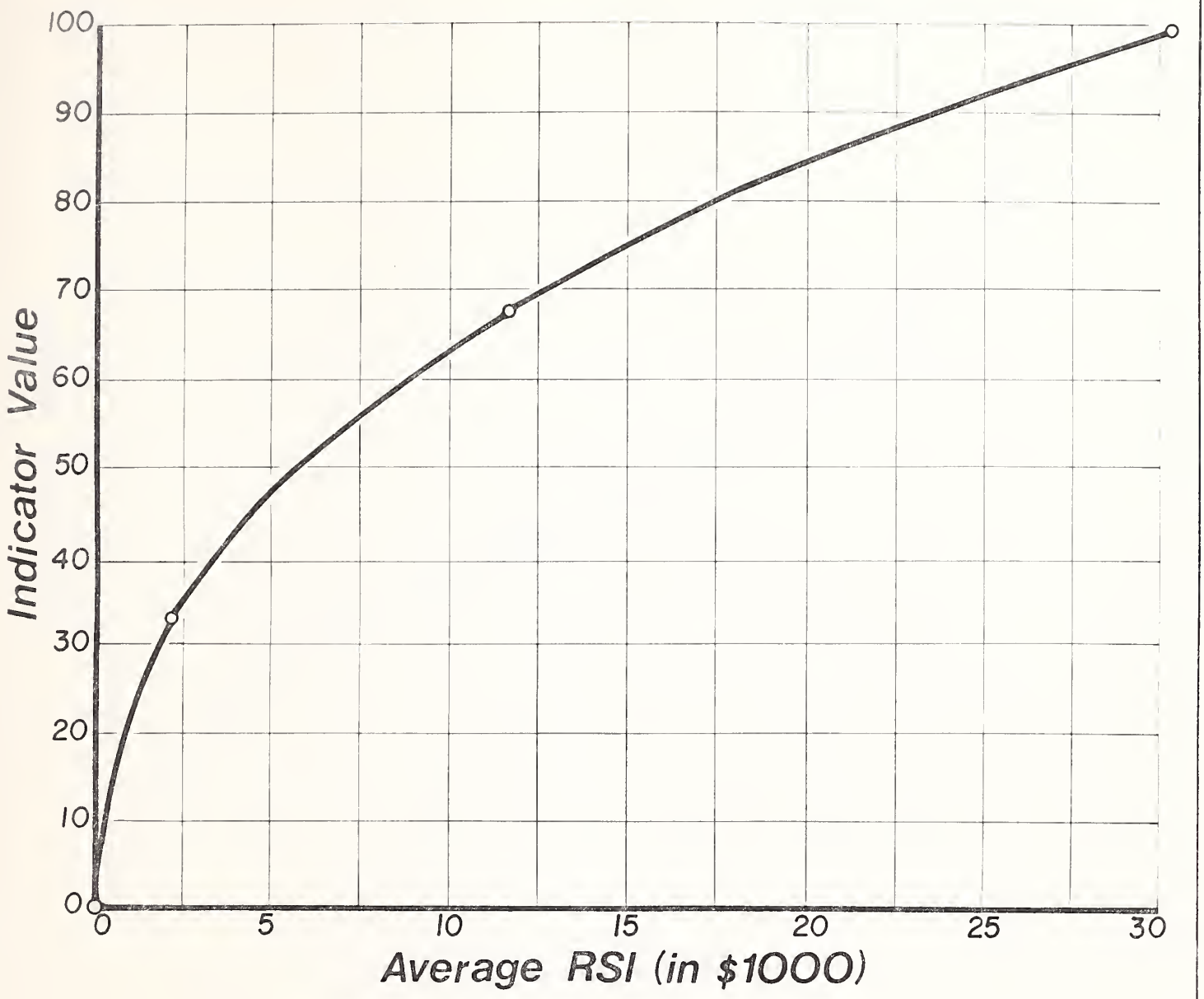
INDICATOR VALUES FOR NUMBER OF ACCIDENTS

FIGURE A3



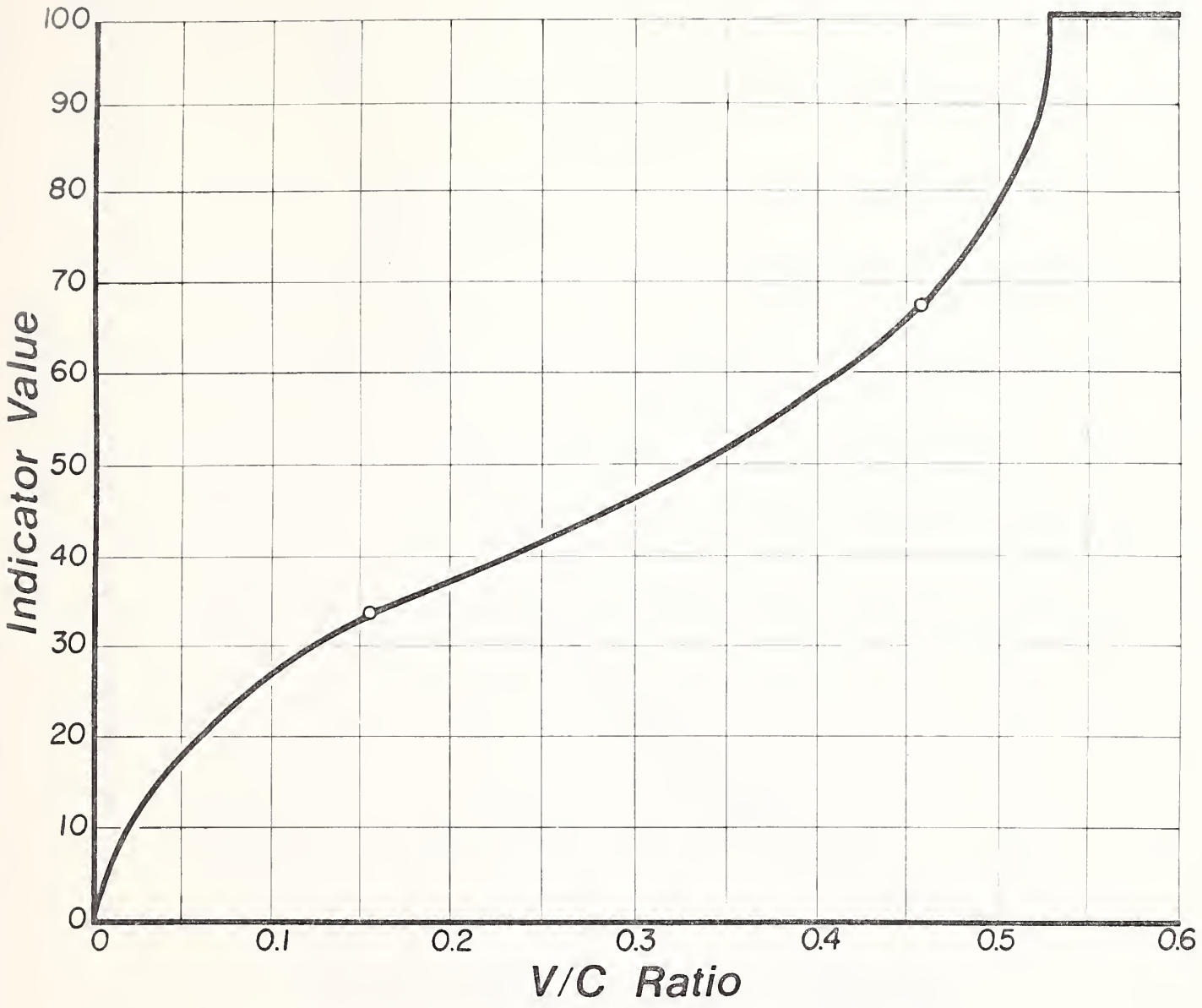
INDICATOR VALUES FOR ACCIDENT RATE

FIGURE A4



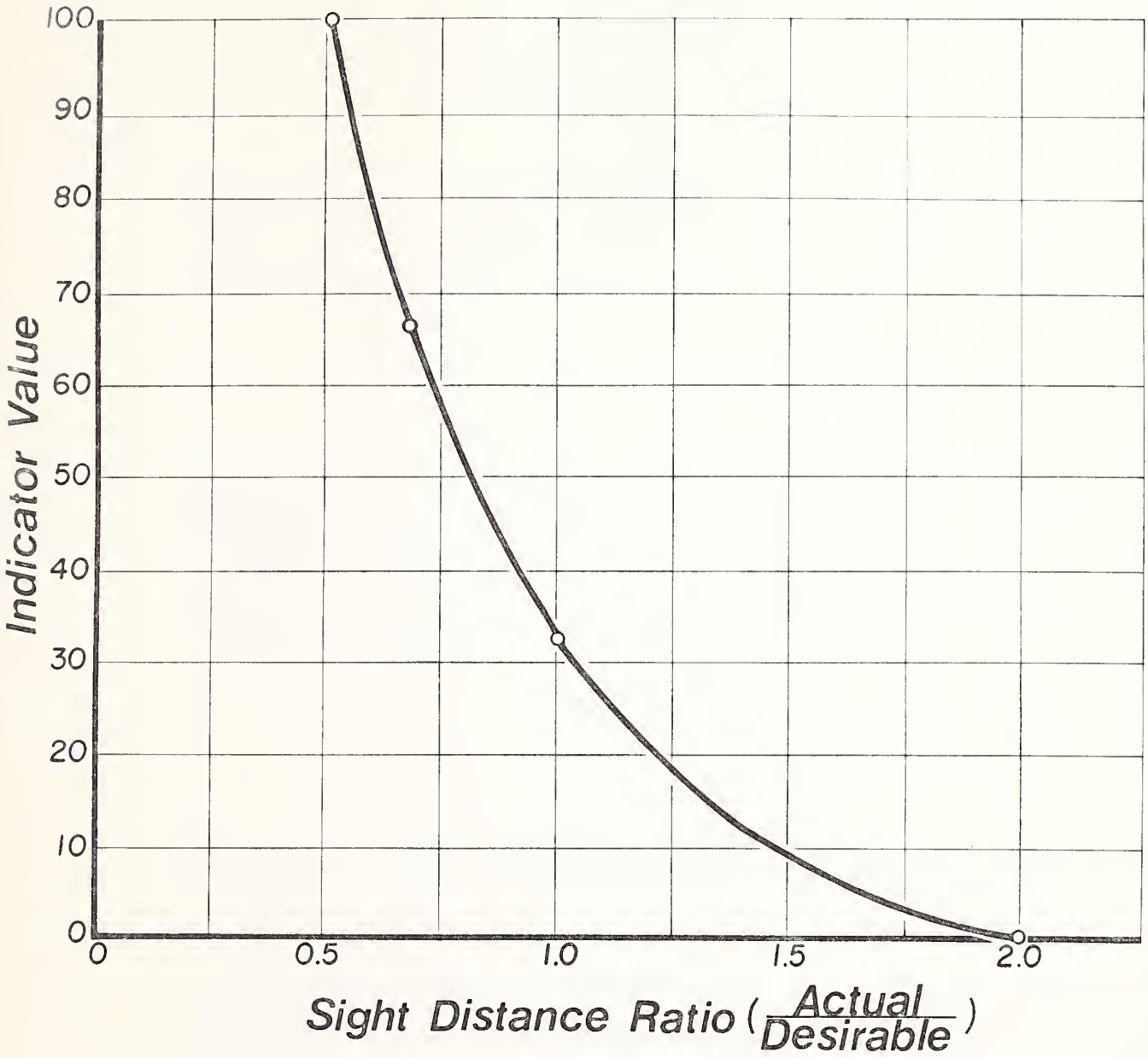
INDICATOR VALUE FOR ACCIDENT SEVERITY

FIGURE A5



INDICATOR VALUES FOR
V/C RATIO

FIGURE A6



INDICATOR VALUES FOR SIGHT DISTANCE

FIGURE A7

DRIVER EXPECTANCY PROBLEMS RATING FORM

Ratings

0 Nothing unexpected or unusual at this location.
Actions required (if any) entirely consistent with driving strategy on approach.
Standard geometry, with pathway(s) for intended movement(s) clearly evident.
No intereferences by other traffic likely.

1

2

3 Situation somewhat unexpected.
Driver must be alert, but should be able to respond adequately at "last minute" to most combinations of adverse circumstances.
Some initial confusion on intended path(s) or movement(s).
Interference from other traffic may create some degree of confusion or uncertainty for average driver.

4

5

6 Very unusual situation; will surprise many unfamiliar drivers.
Driver required to make major changes in driving tactics from those employed over past few miles.
At least a "near accident" almost **expected** if driver is even moderately inattentive; evasive actions likely to be required.
Intended pathway(s) confusing under fairly normal traffic or lighting conditions.
Other traffic, or lack of it, aggravates situation and misleads driver or deprives him of important cues.

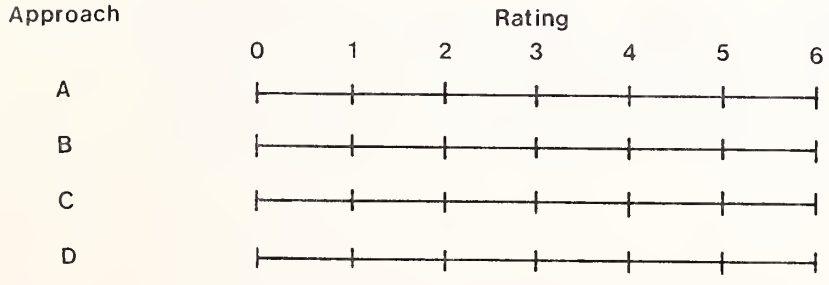
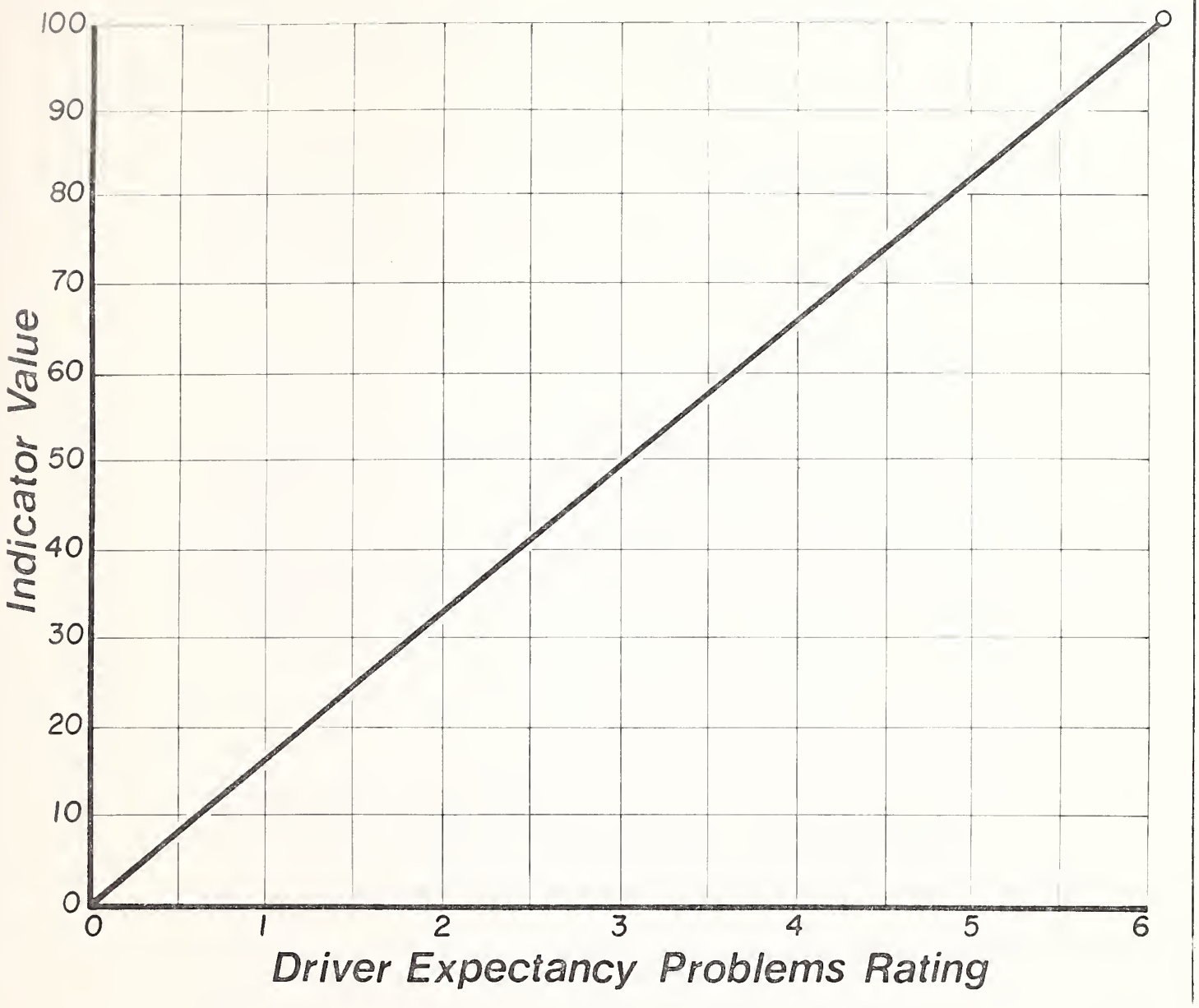


FIGURE A8



INDICATOR VALUES FOR DRIVER EXPECTANCY

FIGURE A9

INFORMATION SYSTEM DEFICIENCIES RATING FORM

Ratings

0 Information for required decisions complete and unambiguous.
Signs, markings, delineation in good repair, clean, highly visible.
"Positive guidance" leads driver to appropriate path; makes "error" difficult.
Approach speeds of most drivers are appropriate.
Light decision load; easy and obvious.

1

2

3 Some information lacking or somewhat misleading.
Signs should be moved or augmented for better visibility or to provide more decision time.
Visibility of signs, marking, and delineation barely adequate.
Medium decision load; average driver will be able to handle situation, but may be a little uncomfortable.

4

5

6 Important information missing.
Complete new "information system" needed – design and installation.
Present signs and markings in very poor condition; need replacement.
Speed limit and/or advisory speed needed; either missing or totally inappropriate at present.
"Positive guidance" on appropriate path lacking; a clutter of negative delineation only.
Heavy decision load; complete attention of average driver required; a "tense" situation at best.

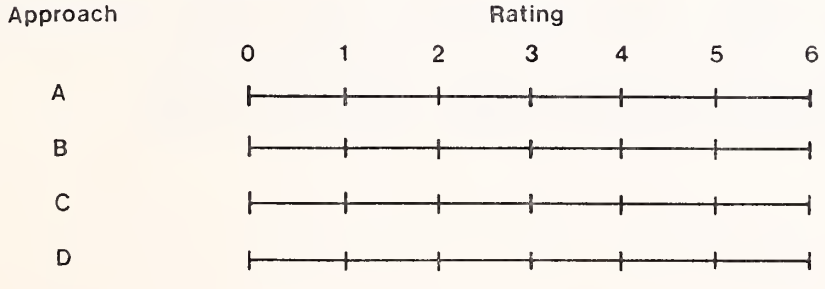
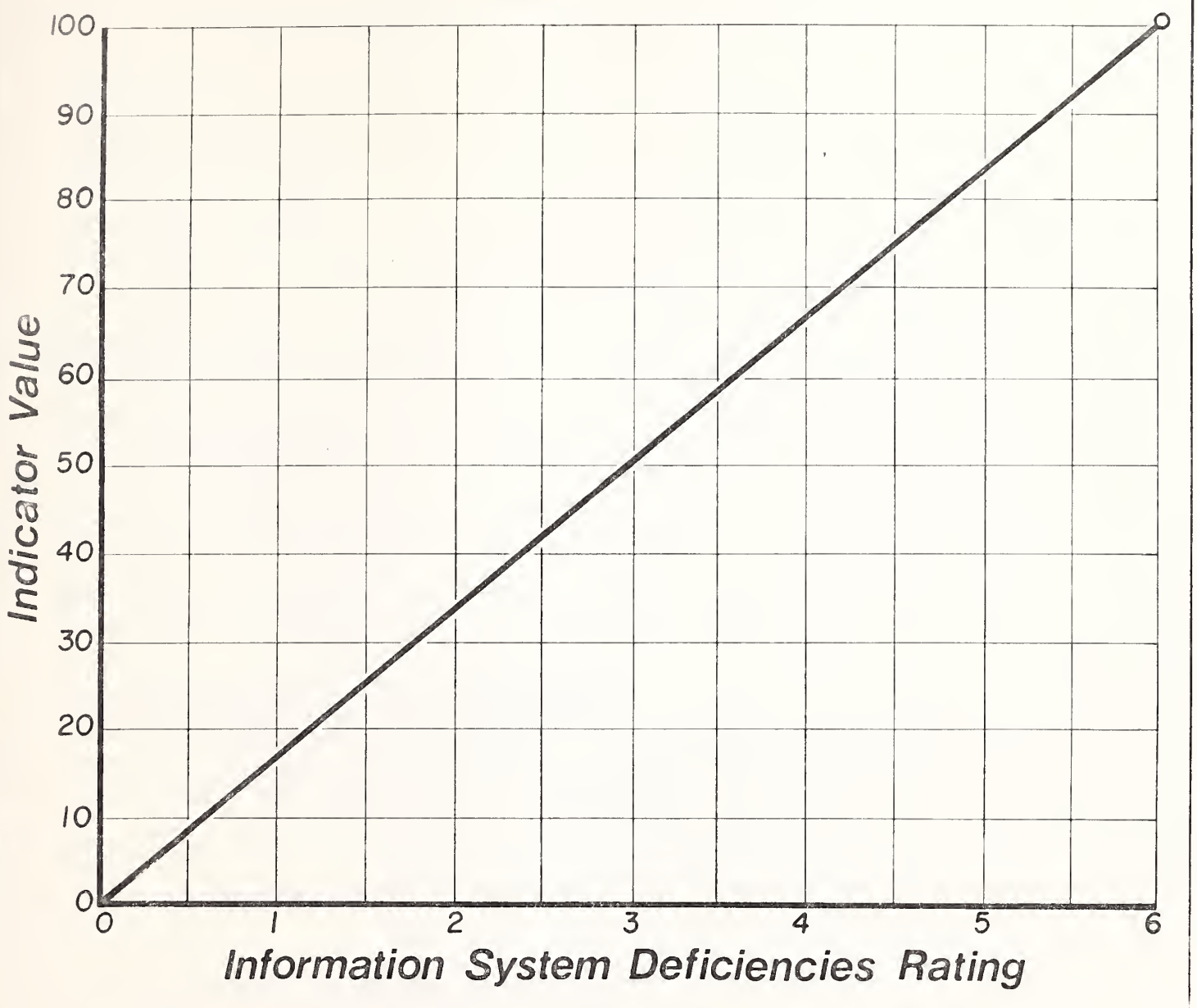


FIGURE AIO



INDICATOR VALUES FOR INFORMATION SYSTEM DEFICIENCIES

FIGURE A11

BENEFIT / COST RATIO WORKSHEET

Location: _____ Milepost: _____

Improvement Description: _____

_____

Estimated Service Life _____ Years = T

Compounded Interest Rate _____ % = R

Current 19___ ADT _____

Time Frame for Accident Data: From _____ To _____ = _____ Years

I. ANNUAL COST FOR THE IMPROVEMENT:

1. C = Capital Cost for Improvement $ _____
2. K = Capital Recovery Factor = $K = \frac{R(1+R)^T}{(1+R)^T - 1}$ = _____
3. M = Change in Annual Maintenance or Operation Cost $ _____
4. Annual Cost = (C K) + M = $ _____

II. ANNUAL BENEFIT OF THE IMPROVEMENT:

1. ADT_a = Average Daily Traffic After Improvement: _____
2. ADT_b = Average Daily Traffic Before Improvement: _____
3. I/F = Ratio of Injuries to Fatalities for the Class of Highway Involved: _____
4. $\frac{Q = * + (I/F)^{**}}{1 + I/F}$ = _____ = _____ = _____

   * Current cost of a fatal accident from National Safety Council memo No. 113 = $ _____

   ** Cost of an injury accident = $_____

5. Afi = Annual average number of fatal accidents and injury accidents combined at the location which will be affected by the improvement =

   $\frac{No.}{Years}$ = _____ = _____

FIGURE A12

6. Apd = Annual Average Number of Property Damage Accidents at the Location =

$\frac{\text{No.}}{\text{Years}}$ = _____ = _____

7. Pfi = Expected Percentage Reduction of Fatal and Injury Accidents by Improvement =

_____ %

8. Ppd = Expected Percentage Reduction of Property Damage Accidents by Improvement =

_____ %

a. P_1 = Largest percentage reduction in accident of any one of the improvements.

b. P_2 = Second largest percentage reduction in accidents of any of the improvements.

c. P_3 = Third largest percentage reduction in accidents of any of the improvements.

d. Pfi and Ppd for location where more than one improvement will be used in combination = $P_1 + \left(\frac{100 - P_1}{100}\right) P_2 + \left(\frac{100 - P_1}{100}\right)\left(\frac{100 - P_2}{100}\right) P_3 + \ldots$

9. Annual Benefit = $\frac{ADT_a}{ADT_b}$ [Q (Afi) pfi + *** (Apd) Ppd] = _____

*** Cost of a property damage accident = $_____

III. BENEFIT / COST RATIO = $\frac{\text{Annual Benefit}}{\text{Annual Cost}}$ = _____ = _____

FIGURE A12 (Continued)

RELATIVE SEVERITY INDEX

BY TYPE OF ACCIDENT *

	Urban	Rural
Multi-Vehicle, At Intersection		
Entering at angle	$4,300	$14,400
From same direction – both going straight	2,800	5,100
From same direction – one turn, one straight	2,500	5,100
From same direction – one stopped	3,800	5,200
From same direction – all others	2,000	6,300
From opposite direction – both going straight	4,000	20,000
From opposite direction – one left turn, one straight	4,400	15,400
From opposite direction – all others	2,700	3,800
Not stated	3,800	5,200
Multi-Vehicle, Non-Intersection		
Going opposite direction – both moving	$4,400	$19,600
Going same direction – both moving	2,900	8,100
One car parked	1,600	2,400
One car stopped in traffic	4,200	6,800
One car entering parked position	1,900	2,300
One car leaving parked position	1,200	2,700
One car entering alley or driveway	3,400	6,000
One car leaving alley or driveway	2,000	4,400
All others	1,700	7,600
Not stated	3,400	6,000
Motor Vehicle with Pedestrian, At Intersection and Non-Intersection		
Vehicle going straight	$20,000	$49,000
Vehicle turning right	13,600	11,200
Vehicle turning left	17,100	11,200
Vehicle backing	20,600	11,200
All others	14,500	11,200
Not stated	11,200	11,200

* FHWA-RD-77-87 "Identification of Hazardous Locations"

TABLE A1

Single Vehicle, at Intersection	Urban	Rural
Collision with train	$26,700	$39,100
Collision with bicycle	13,100	31,900
Injury in vehicle, jacknifed	5,200	2,000
Collision with fixed object in road	5,500	7,000
Overturned in road	9,200	7,500
Left road	5,200	12,300
Single Vehicle, Non-Intersection		
Collision with train	$26,700	$39,100
Collision with bicycle	13,100	31,900
Injury in vehicle, jacknifed	5,200	2,000
Collision with fixed object in road	6,300	9,200
Overturned in road	10,000	9,400
Left road at curve	7,600	12,400
Left road on straight road	5,200	10,500
Other One Motor Vehicle, At Intersection and Non-Intersection		
Fell from moving vehicle	$15,000	$57,200
Collision with animal	4,800	1,800
Collision with other object	4,700	4,400
All others	5,200	2,000
Not stated	3,200	3,400

TABLE A1 (Continued)